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28

SUPPLEMENT NO.1 TO
DESIGN MEMORANDUM NO.13

SACRAMENTO RIVER FLOOD CONTROL PROJECT, CALIFORNIA

Right Bank Yolo Bypass and Left Bank Cache Slough near Junction Yolo Bypass and Cache Slough

LEVEE CONSTRUCTION

GENERAL DESIGN

US Army Corps
of Engineers
Sacramento District

MAY 1986

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SUPPLEMENT NO. 1
TO
DESIGN MEMORANDUM NO. 13
SACRAMENTO RIVER
FLOOD CONTROL PROJECT, CALIFORNIA

RIGHT BANK YOLO BYPASS AND LEFT BANK
CACHE SLOUGH
NEAR JUNCTION YOLO BYPASS AND CACHE SLOUGH
LEVEE CONSTRUCTION

GENERAL DESIGN
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SUPPLEMENT NO. 1 TO DESIGN MEMORANDUM NO. 13
SACRAMENTO RIVER
FLOOD CONTROL PROJECT, CALIFORNIA

GENERAL DESIGN

PERTINENT DATA

1. General

Stream	Yolo Bypass, Cache Slough and Haas Slough
Type of improvement	Levee modification and patrol roads
Purpose	Flood Control

2. Levees

Length of improvement	2.4 miles
Levee enlargement (Cross levee)	3000 linear foot
Maximum height	27 feet
Average height	20 feet
Crown width	20 feet
Freeboard	In excess of 6 feet along Yolo Bypass, in excess of 3 feet along Cache Slough Haas Slough
Bank protection (Cross levee)	3000 linear feet
Landside slope	1V to 3H
Waterside slope	1V to 3H
Landside berm (Cross levee)	40 feet
Waterside berm (Cross levee)	40 feet
Patrol roads (12' width)	3,500 linear feet

3. Hydrologic Data

Project design flow (Yolo Bypass)	490,000 c.f.s.
Project design flow (Cache Slough)	Backwater (Max. W.S. El. 18.4)
Frequencies of exceedence (Yolo Bypass)	About once in 100 years
Frequencies of exceedence (Cache Slough)	About once in 100 years

4. Local Cooperation

Right-of-way (levees)	15.5 acres
Right-of-way (easement or pay severence)	128 acres

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GENERAL DESIGN

SUMMARY OF FIRST COST - SELECTED PLAN

Summary of Federal First Cost

11.	Levees	4,242,000
30.	Engineering and Design	800.000
31.	Supervision and Administration	382,000
	TOTAL FEDERAL COST	5,424,000

Summary of Non-Federal First Cost

01.	Lands and damages	700,000
02.	Relocations	535,000
30.	Engineering and Design	148,000
31.	Supervision and Administration	111,000
	TOTAL NON-FEDERAL COST	1,494,000
	TOTAL FIRST COST	6,918,000

CHAPTER I - INTRODUCTION

1. Project Authorization. - The work included in this unit of the Sacramento River Flood Control Project was authorized by the Flood Control Act of 1 March 1917, Public Law 367, 64th Congress, First Session (House Document No. 81, 62nd Congress, First Session) as modified by the Flood Control Act of 15 May 1928, the River and Harbor Act of 26 August 1937 and the Flood Control Act of 18 August 1941.

2. Purpose and Scope of Supplement. - This supplement presents the general design of the remaining unit of the project and will serve as the basis for subsequent final plans and specifications. The current plan, detailed cost estimates, schedules for design and construction, project operation and maintenance factors, if amended from the previous OCE guidance, real estate requirements, and updated plans for geo-technical investigation are presented herein.

3. Prior Reports. - Letter reports previously submitted to SPD are referenced herein.

a. Office Report dated 29 March 1973 and references quoted therein, subject as above, containing recommendation for work to be done during the 1973 construction season. The work consisted of sealing cracks on one reach of the Yolo Bypass levee and four reaches on the Cache Slough levee, excavating subsided area, and recompacting levee at two sites on Cache Slough.

b. Letter to State Reclamation Board dated 28 January 1974 requesting concurrence in reducing levee freeboard and conditions of transfer of construction work after providing revised freeboard and levee section in the subsidence area.

c. Letter from State Reclamation Board date 14 February 1974 accepting the proposal in reference b above, provided the Sacramento District inspects and maintains the levee for 5 years. The 5-year maintenance period was concurred in by SPD 5th Indorsement dated 26 March 1974 to SPK letter dated 30 March 1973.

d. Office Report dated 23 May 1974, subject as above, reviewing the then current condition of the subsided levees, outlining the construction work proposed for FY 1974 and subsequent stage construction and continued mainenance for a five-year period.

e. Office Report dated 25 February 1975, subject as above, reviewing the then current condition of the subsided levees, outlining the construction work proposed for FY 1975 and subsequent stage construction and continued maintenance for a five-year period.

f. Office Report dated 11 March 1976, subject as above, reviewing the current condition of the subsided levees, outlining the construction work proposed for FY 1975 and subsequent stage construction and continued maintenance for a five-year period.

g. Office Report dated 25 February 1977, subject as above, reviewing the then current condition of the subsided levees, outlining the construction work proposed for FY 1977 and subsequent stage construction and continued maintenance for a five-year period.

h. Office Report dated 6 March 1978, subject as above, reviewing the then current condition of the subsided levees, outlining the construction work proposed for FY 1978 as part of the continuing maintenance program.

i. Office Report dated 1 March 1979, subject as above, reviewing the then current condition of the subsided levees and outlining the construction work proposed for FY 1979 as part of the continuing maintenance program.

j. Office report dated 19 May 1980, subject as above reviewing the then current condition of the subsided levees and outlining the construction work proposed for FY 1979 as part of the continuing maintenance program.

k. SRFCP - Correction of project deficiencies, Cache Slough/Yolo Bypass Levee (Unit 109) and Knights Landing Ridge Cut and Colusa Basin Drain Levees (Units 127 and 132) dated July 1981.

4. Project Background & History. - The section of levee being investigated was originally constructed in the early 1900's predominantly of organic clay and clay materials which were dredged from the adjacent sloughs and channels. In 1959, Design Memorandum No. 13 was issued by the Sacramento District, Corps of Engineers for the improvement of 17.4 miles of Sacramento River Flood Control Project levees along the east bank of Cache Slough and the west bank of Yolo By-Pass. The improvements were to bring up to project standards sections of existing locally built levees which were deficient in grade and cross section and lacking patrol roads. The 2.4-mile section of levee under investigation here is part of the levee system covered by the design memorandum, but not successfully improved by the initial and subsequent construction.

South tip of the Liberty Farm has experienced substantial subsidence and sloughing during the construction period. Construction was progressing under contract No. DA-04-167-CIVENG-61-67 by Eugene Luhr and Co. during the period from 12 April 1961 to 30 November 1961. On 4 August 1961, field investigation of Cache Slough Yolo Bypass levees revealed a 200 feet long subsided area between station W353+00 and W362+00. Since then, subsidence and sloughing at the 2.4 miles of levee between stations W318+00 to C72+00 has continued. Following the second phase of field and laboratory investigations, a three-year staged construction plan was developed for the continued upgrading of the distressed levees to project standards. The plan called for the use of dredged channel material to raise the levee crown to design grade with a project standard cross section over a three-year period, with limitations on the maximum lift of material that could be placed each construction season. The first stage of this additional construction program began in 1962. Because of continued failures and damage from flooding, the original staged construction program was extended, with intervals of deferred construction to allow stabilization of distressed areas. Through 1973, remedial repair and upgrade construction was carried out annually, except during intervals of deferred construction. A review and evaluation of the condition of the problem levee reach was made annually. In February 1974 a

two-phase plan, which would lead to acceptance of this final unit of the project, was agreed to by the Sacramento District and the State Reclamation Board and approved by SPD. The plan provided for stage construction of the subsided levees over a period of about three years (this plan was completed in December 1976) followed by a five-year maintenance period during which the Corps annually inspects and perform such deferred construction as was necessary to maintain required freeboard. Construction repair work was done in 1977, 1978, 1979, and 1980 to bring the project levees to grade. In 1981 additional work was planned but dropped after it was decided to pursue obtaining funds for geotechnical studies to develop a permanent fix. The transfer of responsibility for operation and maintenance of this unit was contingent upon "if no serious subsidence has occurred"; serious subsidence did occur during the five year maintenance period and the State Reclamation Board refused to accept responsibility for operation and maintenance. The levee in this reach has continued to subside and slip. In view of the above, the State Reclamation Board would not accept responsibility for operation and maintenance until the levee in this reach is properly repaired and levee grade stabilized to the authorized grade. In March 1981, OCE issued new policy guidance on correction of project deficiencies. In July 1981, we prepared a reconnaissance report recommending correction of these deficiencies under the authority of the Sacramento River Flood Control Project in accordance with OCE's policy. In September 1982, OCE directed that the Cache Slough/Yolo Bypass levee which has not been transferred for Operation and Maintenance be finalized under the original project authorization. The FY 85 Appropriations Act provided $250,000 to determine alternative solutions to repair the levees in Unit 109; $250,000 are funded in FY 86 to continue these studies.

5. Status of Local Cooperation. - Local interests are required to provide without cost to the United States all lands, easements and rights-of-way necessary for the construction of the project; to hold and save the United States free from damages due to the construction work; to maintain and operate all works after completion in accordance with regulations prescribed by the Secretary of the Army; and to bear the cost of all utility relocations and modifications. The State of California, by legislation passed in 1939 (Senate Bill No. 950), provided the necessary assurances of local cooperation. No cash contribution is required. The agency of the State authorized to handle all matters pertaining to local interest cooperation is the Reclamation Board of the State of California. The Reclamation Board has approved the plan of improvement at the Board Meeting held 21 March 1986.

6. Description of the Project Area. - The project site is located west of the Sacramento River, about 8 miles north of Rio Vista and 19 miles east of Fairfield in Solano County California (Plate 1). More specifically, the study area is a V-shaped levee system that immediately protects a triangular-shaped piece of land which is between Cache Slough to the west and Shag Slough to the east, just north of the sloughs but is essential for the protection of 13,000 acres of land. Hastings Tract is directly west, and Yolo By-Pass and the Sacramento River Deep Water Ship Channel are directly east of the project site. The project site is accessible from the north via paved road north of Liberty Farms, and gravel and dirt roads south of Liberty Farms along Shag Slough. The problem area has been 2.4 miles of existing levee within the project area.

7. General Description. - The selected plan provides for completion of levee construction to project standards with a 6-foot freeboard along the west levee of the Yolo Bypass from traverse station 42+45 whose Coordinates are N 222,575.57, E 2,087,538.96 to Stat. 132+00 on the east levee of Cache Slough whose coordinates are N. 221,926.66, E 2,084,780.50. Patrol roads will constructed on the levee's crown.

This work provides for protection from flood flows which occur less than once in 100 years on the average, and is consistent with completed project levees protecting this area. The work consists of repair approximately 3,000 feet of levee to a stable condition which are deficient in grade and/or section, construction of 3,500 feet of standard 12' wide patrol road, modification of existing irrigation and drainage structures, and construction of road ramps.

Borrow material for the project work on the west levee of Yolo Bypass and the north levee of Cache Slough will be obtained from borrow areas resulting from dredging operation for the Sacramento Deep Water Ship Channel Project on the west side of the ship channel. Location of the borrow area is shown on Plate 12.

8. Departure From Project Plan as described in DM #13. - To stabilize the levee in distress to a design grade, four plans were considered for selection of a most economical plan. Modifying the existing 2.4 miles of the levee, that has been deficient in grade and stability since its construction is more expensive than the alternative plan selected. The selected alternative plan is shown on plate 18 and is described below.

Under this plan, existing levees north of the selected cross levee are repaired without any modifications to the existing section. The new levee, which will join Shag Slough to Cache Slough will have a 1V to 3H slope on the water and land side with a 40 feet berm at elevation 10 (Corps Datum). The detailed cross section is as shown on Plate 20.

9. Hydrology and Hydraulics. - The project design discharges and their stages for the Sacramento River and its principal tributaries were developed for the Sacramento River Flood Control Project in Senate Project Document No. 23, 69th Congress, First Session. These flows and flood plane have since been adjusted over a period of years by records obtained from flood flows up to and including the December 1955 flood. The current project design flows and the project design flood plane are shown on Sacramento District drawing file Number 50-10-3334, dated 15 March 1957, approved by SPD on 20 September 1957. The project design flood plane for the reaches of the Yolo Bypass and Cache Slough under consideration is also shown on Plate III of DM #13. The project design flow of 490,000 c.f.s. (frequency rarer than once in 100 years) in this reach of the Yolo Bypass produces a design flood plane elevation of 18.4 feet and 24.0 feet (Corps of Engineers Datum) at the downstream and upstream limits respectively of the project work unit limits. The design flood plane for the Cache Slough reach of the project is at elevation 18.4 feet (Corps of Engineers Datum). Velocity measurements have not been obtained within the project work unit.

10. Foundation Conditions. - Plate 2, shows the location of explorations and defines the study area. The levee and foundation profile is shown on plate 8 and a typical section of the existing levee is shown on plate 17. It is noted that the ground water level is at or near the landside ground line during the wetter winter months. Based on the explorations and laboratory test results, foundation conditions at the site are briefly summarized in the following paragraphs.

a. Existing Levee Fill

The existing levee fill consists primarily of bluish-grey, fat clay (CH) dredged from the adjacent channels. The levee surface is typically fissured. The fill has an average wet unit weight of 110 pcf with a moisture content of 40 percent. The fill is firm to stiff and has an undrained shear strength of 800 psf.

b. Soft Foundation Beneath Levee

The soft foundation beneath the existing levee fill consists of dark-brown silt (MH) and greyish-black organic silt (OH). This material is very weak and has an average unit weight of 95 pcf with a moisture content on the order of 50 percent. Due to consolidation following levee construction in 1961, an undrained shear strength of 450 pcf is typical of the soils under the levee.

c. Soft Foundation Adjacent to Levee

The soft foundation soils adjacent to the existing levee are similar to the silts under the levee except for unit weight and associated strength. For these soils, an average wet unit weight of 85 pcf with a moisture content on the order of 70 to 75 percent is typical. Since these soils have not been preconsolidated an undrained shear strength of 300 psf was selected for design purposes. It is noted that a shear strength of 380 psf was used for the 1961 levee design and stability analysis.

d. Stiff Foundation

The stiff foundation beneath the soft silts consists of dark brown, sandy clay (CL). These soils are firm to stiff and have an average wet unit weight of 125 pcf with 26 percent moisture. This layer has a significantly higher strength than the overlying soils. Therefore, the layer serves as the lower boundary for potential foundation failure surfaces.

e. Future Explorations and Laboratory Testing. - Proposed future explorations and laboratory testing include the following:

(1) Drilling 5 Pitcher barrel holes, 50 feet deep, 3 inches in diameter along the proposed cross levee alternative 2 alignment. These holes are required to confirm foundation conditions under the proposed cross levee and to provide undisturbed soil samples for laboratory testing.

(2) Primary and secondary laboratory testing will be performed to insure that the physical properties of the foundation soils equals or exceeds the design values used by Wahler Associates to develop the proposed cross levee

section. In addition, classification, strength and consolidation testing will be performed so that slope stability and settlement can be evaluated and compared to design values developed by Wahler Associates. (See para 18d).

11. Borrow Material. - Borrow material from the project will be obtained from a 10 mile long deposit of dredged materials along the west side of the Sacramento River Deep Water Ship Channel, northeast of the existing levee area. This material was excavated from the deep water channel during original construction and subsequent maintenance dredging. This was the closest source of acceptable borrow material in the quantities desired. Dredged materials generally consist of sandy silty clays of medium plasticity and clayey sands to a depth of 10 to 15 feet. The deposits become wet to saturated at about 10 to 15 feet. Therefore, borrow operations would be limited to a depth of about 10 feet. The location of borrow material is shown on Plate 12.

12. Levees and Patrol Roads. - The existing levees will be enlarged and/or modified where they are deficient in cross-section and/or grade. The project plan provides for a 6-foot minimum freeboard along the right bank of the Yolo Bypass and 3 feet along the left bank of Cache Slough. The existing levee section north of the cross levee will require minor fill and shaping of the crown to the project crown width of 20 feet wide with a 1V on 3H waterside levee slope and a 1V on 2H landside levee slope. The new cross levee section will have a crown width of 20 feet with landside and waterside slopes of 1V on 3H with both a landside and waterside berm 40 feet wide at elevation 10 COED. The standard patrol road will be 12 feet in width with 4 inches of stabilized mineral aggregate surfacing. Typical levee section and patrol road details are shown on Plate 20.

Non-Federal responsibilities will also include construction of ramps at borrow sites, culverts for crossing drain canals, costs for rights-of-access, clearing for haul road through the farm lands, upgrading the subbase to bear truck traffic, restoring the haul road back to the original condition. The Non-Federal Sponsor will be responsible for all costs for repair of damages, if any, to the private roads that will be used during construction.

13. Bank Protection. - The proposed bank protection will consist of quarry stone placed on a prepared bank slope to a thickness of 15 inches in accordance with approved standard bank protection shown on plate 20. The prepared slope will be 1V on 3H for the cross levee.

14. Relocations. - The State Reclamation Board is responsible for this work. There are no public roads and utilities that will require modification as a result of the proposed work. Irrigation and drainage canals that are disturbed through this project will be relocated or modified. A new drain pump will be installed since the cross levee will prevent draining the area north of the newly constructed cross levee.

15. Real Estate Requirements. - All lands and rights-of-way for construction in connection with the work unit are to be furnished by local interests. The State Reclamation Board will, prior to the date of advertising for bids, advise the Sacramento District by letter that all rights-of-way and rights-of-entry have been obtained and clearance is given prior to commencing construction. The limits of the right-of-way acquisition including borrow

and spoils areas will be shown on the final contract plans. The selected cross levee alternative will require fee purchase of about 15 acres of land to build the cross levee. It will remove 128 acres of land from project levee protection which will require purchase of a flowage easement or the making of other arrangements. The 128 acres removed from project levee protection will still be protected by the existing levee which will then be classified as a non project levee.

16. Alternative Plans Considered. - Four alternative plans considered under this study, are described below:

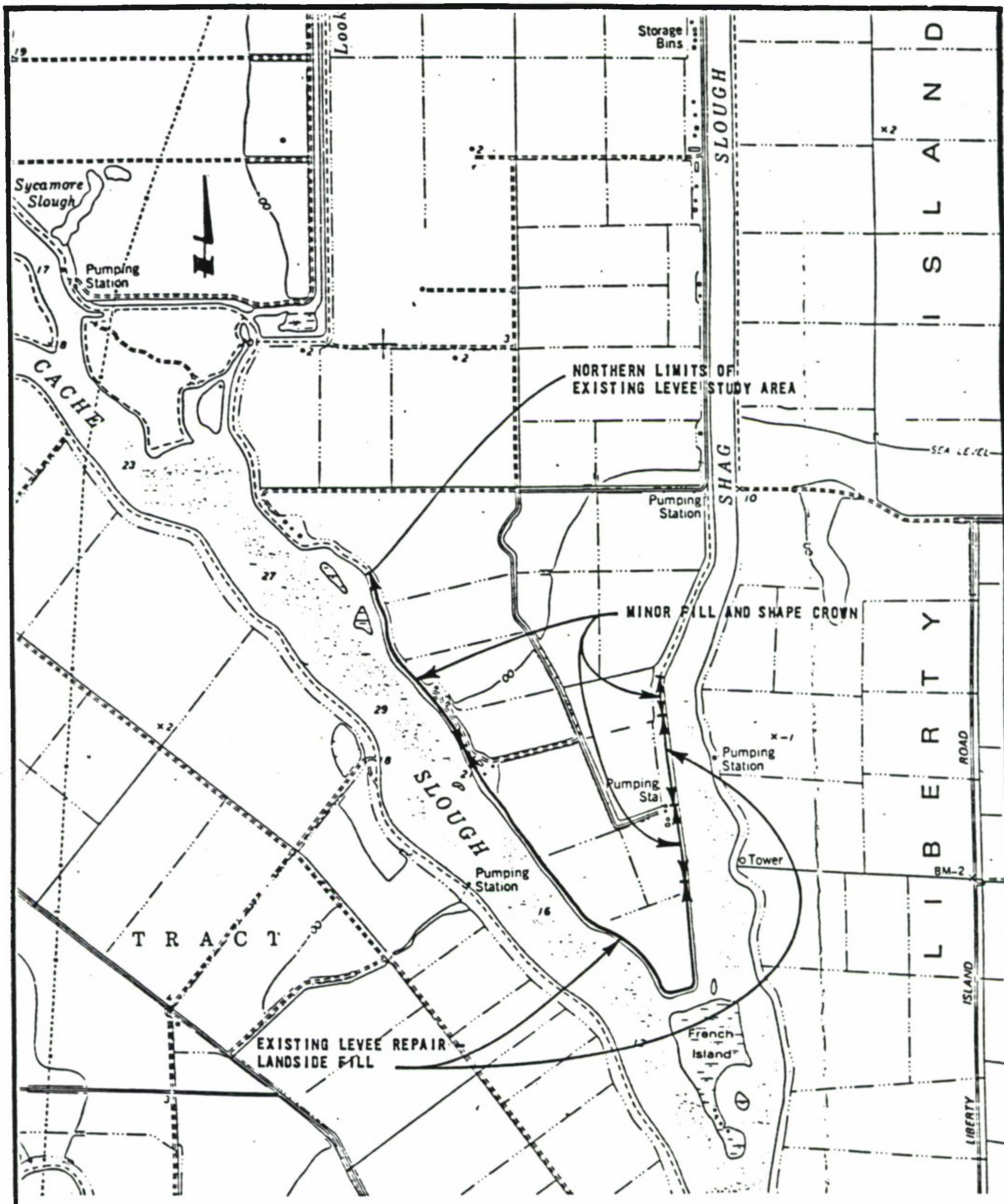
Plan 1: Repair the existing levee with a redesigned cross section and with a minor change in the existing alignment. See Figure II-1.

Plan 2: This plan consists of constructing a cross levee to join the existing levees of Shag Slough and Cache Slough, and repair the existing levees north of this alignment with a redesigned cross section. See Figure II-2.

Plan 3: The same as Plan 2 with a cross levee alignment at a different place. The existing levees north of this cross levee alignment are repaired with providing fill for levee slopes and crown, and the levee cross section remains the same. See Figure II-3.

Plan 4: This plan consists of construction of a cross levee at a site north of the existing levees.

In plans 2, 3, and 4, the levees south of cross levee alignment will not be repaired under this authority. Non-Federal interests could maintain or not maintain these existing levees at their option. See Figure II-4.



BASE FROM USGS CALIFORNIA, 7.5 MINUTE SERIES,
LIBERTY ISLAND TOPOGRAPHIC QUADRANGLE, 1978.

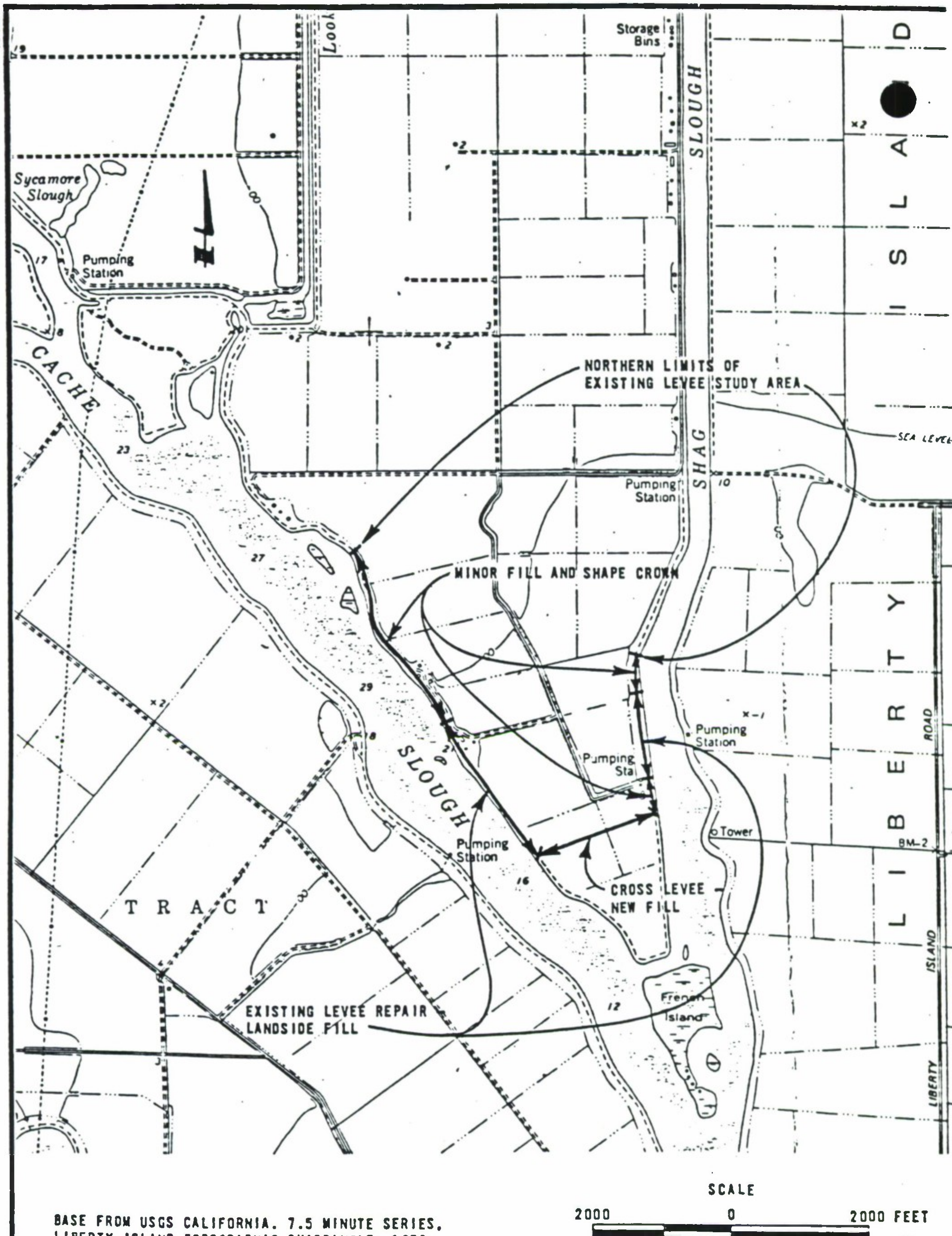
SCALE

2000 0 2000 FEET

LAYOUT PLAN
EXISTING LEVEE REPAIR

CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
SOLANO COUNTY, CALIFORNIA

FIGURE II-1

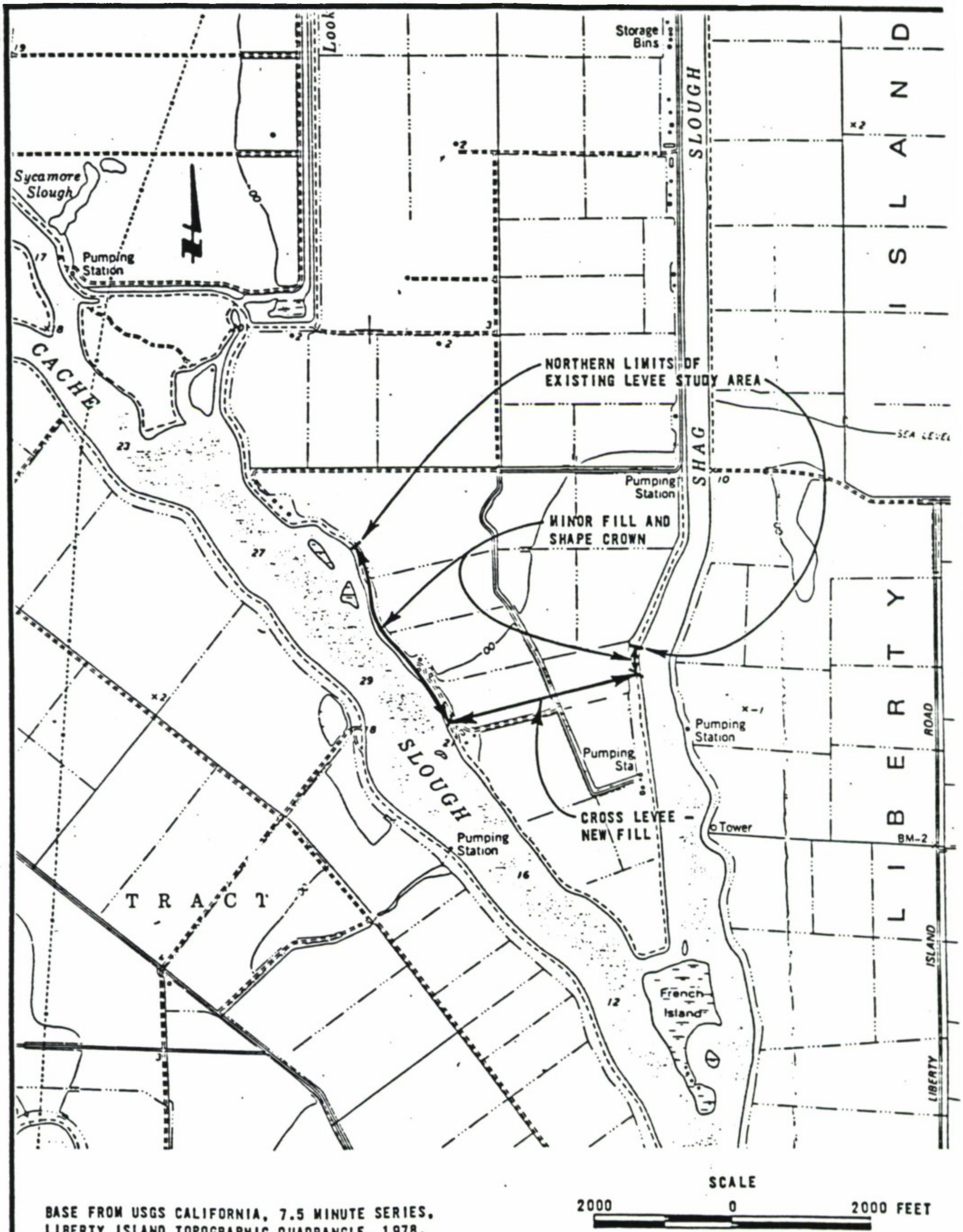


BASE FROM USGS CALIFORNIA. 7.5 MINUTE SERIES, LIBERTY ISLAND TOPOGRAPHIC QUADRANGLE, 1978.

LAYOUT PLAN
CROSS LEVEE – ALTERNATIVE 1

CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
SOLANO COUNTY, CALIFORNIA

FIGURE II-2

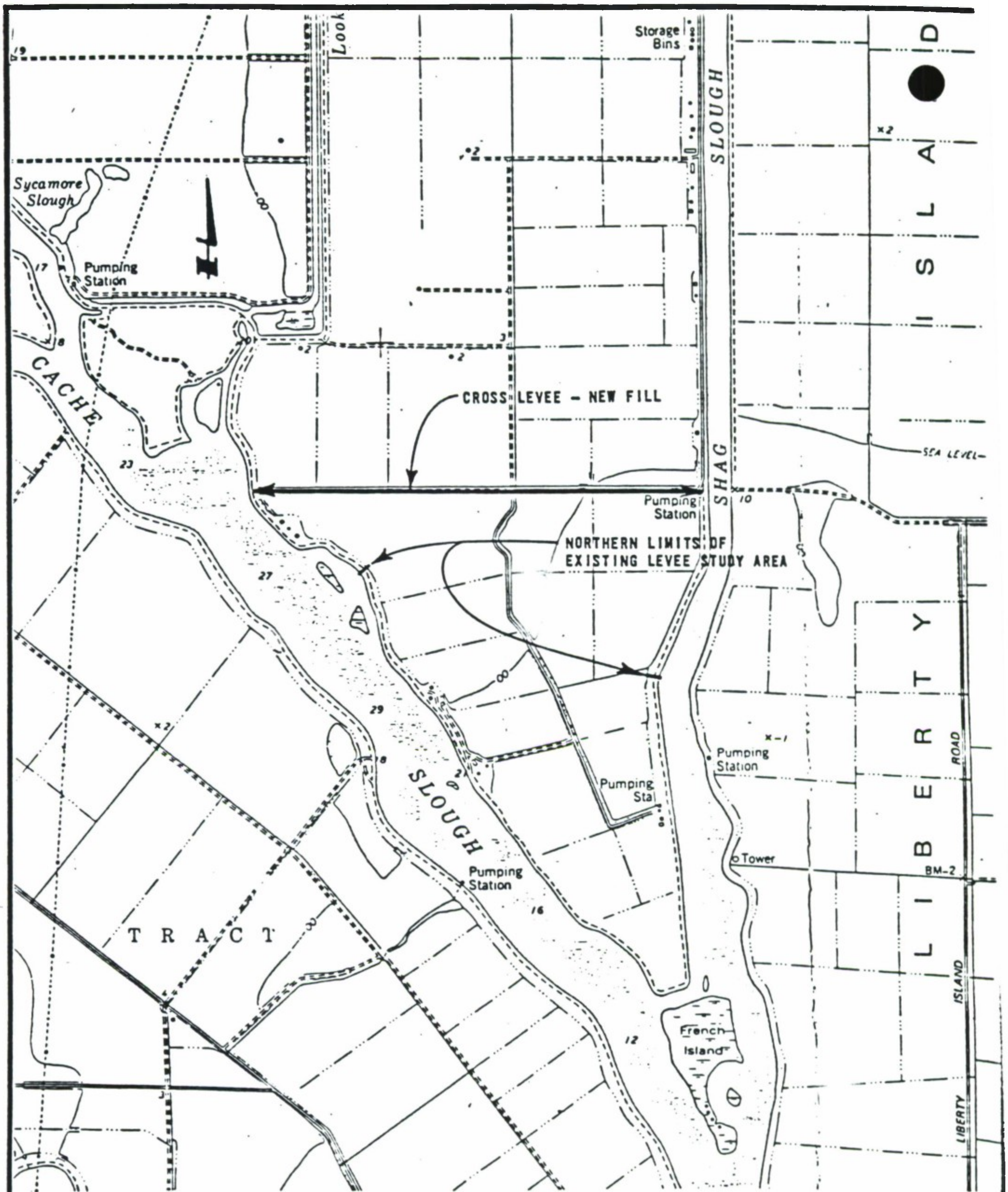


BASE FROM USGS CALIFORNIA, 7.5 MINUTE SERIES, LIBERTY ISLAND TOPOGRAPHIC QUADRANGLE, 1978.

LAYOUT PLAN
CROSS LEVEE - ALTERNATIVE 2

CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
SOLANO COUNTY, CALIFORNIA

FIGURE II-3



BASE FROM USGS CALIFORNIA, 7.5 MINUTE SERIES,
LIBERTY ISLAND TOPOGRAPHIC QUADRANGLE, 1978.

SCALE
2000 0 2000 FEET

LAYOUT PLAN
CROSS LEVEE - ALTERNATIVE 3

CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
SOLANO COUNTY, CALIFORNIA

FIGURE II-4

17. General. An extensive geotechnical investigation of the existing 2.4 miles of the levee as well as area surrounded by these levees was throughly investigated under a contract No. DACW05-84-D-0089, Delivery Order No. 4 dated 8 February 1985, modification to Delivery Order No. 4 dated 2 April 1985, Delivery Order No. 7 dated 12 April 1985 and Delivery Order No. 8 dated 16 April 1985 with the firm of Wahler Associates. Their investigation and findings were reported to Sacramento District in a Design Report Volume I and Volume II dated October 1985.

18. Existing Levees Investigation.

a. Background. Prior to the development of Design Memorandum No. 13, a field and laboratory investigation was carried out by the Sacramento District, Corps of Engineers in 1958 for the main purpose of evaluating the properties and characteristics of the existing levee embankment and foundation materials within the levee improvement project area. The logs of borings made during this investigation within the subject 2.4-mile study area and the results of laboratory testing summarized by the Corps of Engineers are provided on Plate 3. The locations of these borings are provided on Plate 2, and these borings are also shown on a levee and foundation profile developed as part of the existing levees investigation (Plate 8). The explorations during this initial investigation indicated that within the 2.4-mile study area, foundation conditions consisted of generally a 20-foot thick maximum layer of predominantly highly plastic organic silt and clay, underlain by a firm clay layer of undetermined depth. Foundation conditions directly under project levees to the north (planned for upgrading under Design Memorandum No. 13 but outside of the 2.4-mile study area,) consisted of generally firm clay and sandy clay materials.

Levee upgrading construction under Design Memorandum No. 13 started in 1961. The 2.4-mile reach of levee under investigation by this study failed during construction and has been repeatedly repaired between 1961 and 1980. The upgrading of sections of existing levee deficient in grade and cross section called for raising the existing levee crown and widening the section on the landside as necessary to estabish a project standard 20-foot wide crown with 3 horizontal to 1 vertical waterside and 2 horizontal to 1 vertical landside slopes. The failures that occurred during the initial construction and subsequently during and between periods of remedial construction have been attributed mainly to overloading the crest of the levee. Major signs of distress in failed areas included subsidence, cracking, and lateral movement.

Following the start of stability and subsidence problems during the 1961 upgrading construction, a second field and a laboratory investigation was carried out in 1962 for the primary purpose of further evaluation of the properties and characteristics of the exisiting levee foundation materials in distressed areas. The logs of borings made in the levee foundation during this investigation and the results of laboratory index properties testing, strength testing, and field and laboratory vane shear testing performed by the Corps of Engineers are summarized on Plate 4. The locations of the borings are provided on Plate 2, and the borings are also shown on the levee and foundation profile referred to earlier (Plate 8).

b. Field Investigation. - Field explorations for the existing levees investigation were carried out in three stages. The first stage included field vane shear testing, and drilling and undisturbed sampling of an initial exploratory boring in the existing levee fill and foundation within the 2.4-mile study area. The second phase of exploration consisted of drilling and undisturbed sampling of exploratory borings in the existing levee fill and underlying foundation and also in the unloaded foundation adjacent to the existing levee. The third stage involved additional field vane shear testing in the interior of the island. The location of all explorations are shown on Plate 2. For a detailed description of the work carried out during the field explorations, refer to the discusssion at the beginning of Appendix A in "Design Report Volume II-Cache Slough Yolo Bypass Levees" prepared by Wahler Associates.

The field vane shear testing was performed to measure the in-situ undrained shear strength of the levee embankment and foundation materials and to acquire this information in detail versus depth. The field vane borings were made at locations desired by the Corps of Engineers as called out in the scope of work. The seven borings made in the existing levee fill and foundation were spaced out over the 2.4-mile study area and were located primarily in areas currently exhibiting distress or having a history of instability. The three borings in the island interior were made at locations selected to represent typical foundation conditions for a cross levee. Logs of the field vane borings which present the results of the field vane shear testing appear on Plate 7.

The exploratory drilling was performed to obtain continuous undisturbed samples of the levee embankment and foundation materials for examination, classification, and laboratory testing; to correlate the field vane shear test data with the properties of the soil penetrated; and to install piezometers. The initial boring, 7F-1-85, made during the first phase of exploration was located adjacent to one of the fields vane borings for correlation in a section of the study area having a history of problems, where a lot of data from previous investigations exists, and where the greatest subsidence is currently exhibited.

Since the results of the field vane shear testing did not indicate any particular areas strikingly weaker or stronger than others and correlation of strength with depth or material type were not obvious from the results of the first phase of exploration, the locations for additional exploratory borings, 7F-2-85 and 7F-4-85, were based on the following considerations:

- Selecting locations that would be representative.
- Selecting locations adjacent to field vane borings for added correlation.
- Selecting locations that are currently more distressed or have had a history of more problems.
- Selecting locations where data from previous investigations is less available.

At the location of 7F-2-85, borings 7F-3-85 and 7F-3A-85 were drilled at the landside toe to obtain information on unloaded foundation materials. Two supplemental borings, 7F-5-85 and 7F-6-85, were made at locations designated

by the Corps of Engineers, north of the existing levee study area, at the ends of one cross levee alternative alignment. Piezometers were installed in the four holes drilled through the existing levee into the foundation during the second phase of field exploration.

The logs of borings for the exploratory drilling are presented on Plates 5 and 6. The exploratory borings along with the field vane borings are also shown on the levee and foundation profile on Plate 8.

c. Laboratory Investigation. - The laboratory program for the existing levees investigation consisted of visual examination and classification of all undisturbed samples, index properties testing, and engineering properties testing. The index properties testing included the determination of natural water content and in-place dry density, grain-size distribution, Atterberg limits, specific gravity, and organic content. The engineering properties testing consisted of consolidation, torvane shear, unconfined compression, direct shear, and triaxial compression testing. For a detailed description of the laboratory testing procedures, refer to the discussion at the beginning of Appendix B in Volume II "Design Report-Cache Slough Yolo Bypass Levees" prepared by Wahler Associates. The laboratory sample logs and individual test results are also found in Appendix B of that report.

In developing the laboratory testing program and selecting the samples for various tests, the following objectives were considered:

- Representative coverage for index properties testing over the borings and depths explored and various material types encountered.
- Engineering properties testing of materials judged to be the weakest and softest, based on observations during exploratory drilling, the results of visual examination, field vane shear test results, and index properties testing.
- Strength testing of the same or similar materials by a certain number of different types of tests for correlating strength and test type.
- Representative coverage for strength testing over the borings and depths explored and various material types encountered, by the formulation of a cost-effective program using various types of strength tests on the various samples from different borings and reliance on the correlation of strength and test type from the previous objective.
- Engineering properties testing of the same materials from adjacent borings in the loaded and unloaded levee foundation for comparison of properties under the two conditions.

The results of index properties tests and undrained shear strength tests, including field vane shear tests adjacent to exploratory borings, are provided in tabular form on the logs of borings on Plates 5 and 6. Natural water content, dry density, Atterberg limits, and undrained shear strength test results are also presented in graphical form for each exploration boring on Plates 9 and 10. The results of consolidated undrained and consolidated drained shear strength tests and consolidation tests for the levee embankment and foundation materials are presented on Plate 11.

d. Summary of Results and Selection of Design Parameters. - Based on the results of the field and laboratory investigations, three material designations were established for the purpose of summarizing material properties and establishing design parameters. These material designations are shown on the schematic of the existing levee and foundation on Plate 11 and are listed below:

- Existing levee fill.
- Softer foundation.
- Stiffer foundation.

In addition, the softer foundation beneath the existing levee is differentiated from the unloaded foundation beyond the toe of the existing levee. The findings from the field and laboratory investigations are consistent with previous investigations in that the existing levee foundation within the 2.4-mile study area consists of a softer and weaker layer of highly plastic organic silt and clay overlying a significantly stiffer clay. None of the results from field and laboratory observations and testing provided any basis for representing the fill and foundation conditions in any more detailed a fashion than that represented by the material designations established above.

The existing levee embankment fill within the 2.4-mile study area generally consists of a sandy clay of high plasticity. The estimated foundation line shown on the levee and foundation profile on Plate 8 at the locations of exploratory borings indicates that the embankment fill is generally on the order of 20 feet in height. The foundation beneath the existing levee within the study area generally consists of a softer and weaker stratum of alternating layers of silty clay and organic silt of high plasticity, underlain by a stiffer stratum of sandy clay of medium plasticity. The estimated surface of the stiffer foundation shown on the profile on Plate 8 at the locations of field vane borings and exploratory borings indicates that the softer foundation is generally on the order of 20 feet in thickness. Ground water conditions determined from the measurement of piezometers installed during exploratory drilling indicate water levels at or below the estimated foundation line and near or somewhat below the low tide level of the adjacent sloughs.

Based on an evaluation of the field and laboratory test results, the design parameters shown in the table on Plate 11 were selected for later use in design analyses. The following sections provide a summary of the existing levee embankment and foundation material properties and also discuss the basis for the selection of design parameters.

(1) Gradation Characteristics. - The results of gradation tests on samples of material from the existing levee fill and foundation are summarized on three charts on Plate 11, The average percent sand-sized particles and silt and clay-sized particles for the samples tested are summarized in Table III-1, and Plate 1.

(2) Plasticity Characteristics. - The results of Atterberg limits determinations on samples of existing levee fill and foundation materials are summarized on Plate 11. All of the samples of existing levee fill material

tested, except two, have a liquid limit greater than 50 percent, which indicates they have a high plasticity, and all of these samples, except one, plot above the "A" line, indicating a clay consistency. The exception plots just below the "A" line. All of the samples of softer foundation material tested, except one, have a high plasticity and plot both above and below the "A" line, indicating both clay and silt consistencies. All of the samples of stiffer foundation material tested have a medium to high plasticity and plot above the "A" line, indicating a clay consistency. The plastic limit, liquid limit, and plasticity index ranges for the samples tested are summarized in Table III-2.

(3) Natural Water Content and Dry Density. - The results of 107 natural water content and 94 dry density tests on undisturbed samples of existing levee fill and foundation materials are listed in Table B-1 in Appendix B, Volume II, "Design Report" October 1985. The ranges of natural water contents and dry densities for the sample tested, along with the moist unit weights selected for use in design analyses, are summarized in Table III-3. In no case was the natural moisture content found to exceed the liquid limit in the levee embankment fill. However, this condition was found to exist in the case of two tests at locations near the bottom of the softer foundation and is judged to be the general trend near the bottom of the softer foundation within the study area, as is evidenced by the natural water content plots on Plates 9 and 10.

(4) In Situ Undrained Shear Strength. - The determination of in situ undrained shear strength properties of existing levee fill and foundation materials was made from field vane shear testing and unconfined compression and triaxial compression testing on undisturbed samples. The use of a pocket penetrometer during field sampling and torvane shear testing during laboratory sample logging assisted in correlating materials and strengths. Reference is made to the logs of field vane borings on Plate 7 and the results of undrained shear strength testing presented in graphical form for each exploration boring on Plates 9 and 10.

The range of lowest in situ undrained shear strengths determined from field vane shear testing in each of the field vane borings and the range of undrained shear strengths determined from unconfined compression tests and unconsolidated undrained triaxial compression tests for the undisturbed samples tested are summarized in Table III-4.

The strengths measured by the various types of tests compare reasonably well as seen by the plots on Plates 9 and 10. Strengths measured by the unconfined compression test are generally lower than others. No particular trends in strength as a function of depth or material type is evident from the plots. The selection of in situ undrained shear strengths for use in design analyses was based on picking lower bound values below a majority of the data with most weight given to field vane shear and unconsolidated undrained triaxial compression tests. The in situ undrained shear strengths selected for use in design analyses, based on the field and laboratory test data, are indicated in the table of design parameters on Plate 11 and are also listed in Table III-4. It is noted that as a result of the outcome of initial stability analyses, the undrained shear strengths for use in design anlayses was based on picking lower bound values below a majority of the data with most weight given to field vane shear and unconsolidated undrained triaxial compression tests. The in situ undrained shear strengths selected

for use in design analyses, based on the field and laboratory test data, are indicated in the table of design parameters on Plate 11 and are also listed in Table III-4. It is noted that as a result of the outcome if initial stability analyses, the undrained shear strenghts of foundation materials, selected for use in design during the existing levees investigation, as presented here, were subsequently reduced for final design analyses. This will be explained in greater detail under "Soil Design", paragraph 20.

(5) Consolidated Undrained Shear Strength. - Twelve consolidated undrained triaxial compression tests and 14 consolidated undrained direct shear tests were performed on undisturbed samples of existing levee fill and softer foundation materials. The specimens were consolidated under a range of pressures to encompass anticipated remedial repair loading conditions and were then failed in an undrained condition. Pore pressures were measured during the triaxial tests so that shear strength parameters for both the total stress and effective stress conditions could be determined. Two consolidated drained direct shear tests were performed on the softer foundation material for comparison purposes. The confining pressures on the samples ranged from 5 to 35 psi. The total stress and effective stress shear strength results of the triaxial compression and direct shear tests for the existing levee fill and softer foundation materials are summarized on four charts on Plate 11 in the form of Mohr-Coulomb strength envelopes.

The design envelopes selected for use in defining soil parameters for stability analyses are also indicated on the four charts on Plate 11. They are based on selecting lower bound envelopes below the test data. The consolidated undrained total stress and effective stress strength parameters selected for use in design analyses for the existing levee fill and softer foundation are indicated in the table of design parameters on Plate 11. Basically, no differentiation was made for these design parameters for the softer foundation beneath the existing levee fill as opposed to beyond the toe of the existing levee considering that these are consolidated strength parameters.

(6) Consolidation. - Five consolidation tests were performed on undisturbed samples of softer foundation material in order to evaluate the settlement characteristics of the most compressible materials. The results of the consolidation tests are summarized on two plots on Plate 11 in the form of void ratio versus log of pressure curves. As one would expect, there is a dramatic difference between the compressibility of the softer foundation material beyond the toe of the existing levee, which is unloaded, and the compressibility of the softer foundation material beneath the existing levee, which has experienced the effects of load from the overlying levee for some time. Consolidation parameters for the most compressible materials tested were selected for use in design analyses and are indicated in the table of design parameters on Plate 11.

TABLE III-1

EXISTING LEVEES INVESTIGATION
GRADATION CHARACTERISTICS

Material[1] Designation	Number of Tests	Average Percent[2] Sand	Average Percent[3] Silt and Clay
1	9	10	90
2A and 2B	14	3	97
3	5	12	88

[1] 1 - Existing levee fill.
2A and 2B - Softer foundation.
3 - Stiffer foundation.

[2] Between the No. 4 and No. 200 sieve sizes.

[3] Minus No. 200 sieve size.

TABLE III-2

EXISTING LEVEES INVESTIGATION
PLASTICITY CHARACTERISTICS

Material[1] Designation	Number of Tests	Plastic Limit Range, percent	Liquid Limit Range, percent	Plasticity Index Range, percent
1	9	15-40	38-90	21-50
2A and 2B	13	31-56[2]	62-95[2]	31-55
3	5	17-24	38-62	21-38

1 1 - Existing levee fill.
2A and 2B - Softer foundation.
3 - Stiffer foundation.

2 Excludes one exceptional sample of medium plasticity.

TABLE III-3

EXISTING LEVEES INVESTIGATION
NATURAL WATER CONTENT AND DRY DENSITY

Material[1] Designation	Natural Water Content: Number of Tests	Natural Water Content: Data Range, percent	Natural Dry Density: Number of Tests	Natural Dry Density: Data Range, pcf	Selected Design Moist Density, pcf
1	35	14-81	30	52-112	110
2A	50	24-114	44	39-84	95
2B	9	59-131	7	37-62	85
3	13	21-31	13	91-106	125

[1] 1 - Existing levee fill.
2A - Softer foundation beneath existing levee (loaded).
2B - Softer foundation beyond toe of existing levee (unloaded).
3 - Stiffer foundation.

TABLE III-4

EXISTING LEVEES INVESTIGATION
IN SITU UNDRAINED SHEAR STRENGTH

Test	In Situ Undrained Shear Strength Range, tsf — Material Designation[1]: 1	2A	2B
Field Vane Shear[2]	0.38-0.77	0.32-0.56	0.21-0.58
Unconfined Compression[3]	0.18-1.07	0.18-0.62	0.29-0.30
Unconsolidated Undrained Triaxial Compression[4]	0.40-0.79	0.39-0.72	0.34
Selected Design value	0.4	0.3[5]	0.2[5]

1 1 - Existing levee fill.
2A - Softer foundation beneath existing levee (loaded).
2B - Softer foundation beuond toe of existing levee (unloaded).

2 Range of lowest strengths from the following borings: Materials 1 and 2A: FV-1-85 through FV-7-85, Material 2B: FV-8-85 through FV-10-85.

3 Number of tests: Material 1: 5, Material 2A: 8, Material 2B: 2.

4 Number of tests: Material 1: 3, Material 2A: 8, Material 2B: 1.

5 Subsequently lowered for final design analyses. See Under Soil Design paragraph 20.

19. Borrow Investigation

a. General. - Two areas were designated by the Sacramento District, Corps of Engineers for borrow investigation. The locations of the potential sources are indicated on Plate 12. One area, designated Potential Borrow Area A, is an approximately 10-mile long deposit of dredged channel materials along the west side of the Sacramento River Deep Water Ship Channel, northeast of the existing levee study area. The dredged materials are confined between two levee systems on the west bank of the ship channel. The designated borrow area extends from the future turning basin at the north end to Prospect Slough at the south end. The estimated maximum haul distance from the borrow site to the study area is on the order of 18 miles. The second site, designated Potential Borrow Area B, is the interior of the "island" protected by the existing levees under investigation.

b. Field Investigation. - Field exploration for the borrow investigation consisted of drilling and sampling nine shallow exploratory borings along the northern half of Borrow Area A and three exploratory borings in the "island" interior at Borrow Area B. The locations of all explorations are shown on Plate 12. For a detailed description of the work carried out during the field explorations, refer to the discussion at the beginning of Appendix A in Volume II of Design Report, October 1985.

The exploratory drilling was performed to obtain bulk samples of the potential borrow materials for examination, classification, and laboratory testing, and to estimate ground water conditions. At Borrow Area A, six exploratory borings, 2B-1-85 through 2B-6-85, were drilled initially at a spacing of approximately one mile along the northern half of the designated site where access is closest. The locations were selected to provide a representative coverage of an area estimated to contain a sufficient quantity of material for remedial repair to the existing levees under investigation. Three additional borings, 2B-7-85 through 2B-9-85, were made between initial borings for added detail. As indicated on Plate 12, the southern portion of Borrow Area A is considered a potential additional source of borrow, available as needed. The three exploratory borings, 2B-10-85 through 2B-12-85, drilled at Borrow area B were spaced out within the interior of the island from north to south to encounter materials representative of the designated site. The logs of borings for the exploratory drilling are presented on Plate 12.

c. Laboratory Investigation. - The laboratory program for the borrow investigation consisted of visual examination and classification of samples, index properties testing, and engineering properties testing. The index properties testing included the determination of natural water content, grain-size distribution, Atterberg limits, and specific gravity. The engineering properties testing consisted of compaction, consolidation, triaxial compression, and permeability testing. For a detailed description of the laboratory testing procedures, refer to the discussion at the beginning of Appendix B in Volume II "Design Report Vol. I & Vol. II - Cache Slough Yolo Bypass Levees". The laboratory sample descriptions and individual test results are also found in Appendix B of that report.

The results of field exploration indicated that the material encountered in Borrow Area A is of superior quality to that encountered in Borrow Area B for use as borrow for the remedial repair. Potential borrow materials from Borrow Area A are sandier, have much lower natrual water contents, are

significantly less plastic, and are less organic than material that would be derived from Borrow Area B. This translates to a construction material with much greater workability and less susceptibility to cracking from desication. As a result of the field investigation, Potential Borrow Area A was viewed as the primary borrow site, based on the following considerations:

- Superior quality of material for levee fill that would come from Borrow Area A as compared to Borrow Area B.

- Anticipated shallow ground water conditions in Borrow Area B which would dictate very shallow borrow over large areas.

- Required deep stripping in Borrow Area B to remove undesirable highly organic material, which further limits available volume over a given area.

- Uncertainty regarding the ability to acquire land for borrow from Area B.

As a result, a majority of the laboratory testing was performed on representative materials from Borrow Area A, and the results of this testing provided the basis for the selection of design parameters.

In developing the laboratory testing program and selecting the samples for various tests, the following objectives were considered:

- Representative coverage for index properties testing over the borings and depths explored and various material types encountered.

- Compaction testing covering the range of material types that are anticipated for use.

- Strength, consolidation, and permeability testing covering the range of material types that are anticipated for use within the budgetary constraints of the program, but particularly on the weakest, most compressible, and most permeable of these materials as judged from visual examination and index properties testing results.

- Strength, consolidation, and permeability testing on samples fabricated to anticipate field conditions.

The results of index properties tests are provided in tabular form on the logs of borings on Plate 12. The results of compaction tests, unconsolidated undrained and consolidated undrained shear strength tests, consolidation tests, and permeability tests are presented on Plate 13.

d. Summary of Results and Selection of Design Parameters. - The dredged materials explored along the ship channel in Borrow Area A generally consist of sandy and silty clays of medium plasticity and clayey sands overlying a stratum of sand and silty clay of high plasticity. The deposits of medium plastic clay and clayey sand are between 10 and 15 feet deep and become very wet to saturated, generally a few feet above the surface of the underlying highly plastic clay. Therefore, borrow operations would be limited to a depth on the order of 10 feet. Based on an estimated average width of 125 feet and depth of 10 feet of available material over the investigated 6-mile portion of 10-mile long designated area and an estimated shrinkage factor of 15 percent, which yeields an estimated quantity of 1,250,000 cubic yards, it becomes

evident that there is more than sufficient quantity of borrow available from Borrow Area A when comparison is made to the required volumes provided in Chapter V. The near-surface materials that would be obtainable for use from Borrow Area B generally consist of sandy and silty clays and organic silt of high plasticity.

Based on an evaluation of the laboratory test results, the design parameters shown in the table on Plate 13 were selected for later use in design analyses. The following sections provide a summary of the borrow material properties and also discuss the basis for the selection of design parameters.

(1) Gradation Characteristics. - The results of 15 gradation tests on samples of the various materials encountered in Borrow Area A are summarized on Plate 13. Based on the 15 tests, the materials contain an average of 27 percent sand-sized particles (between the No. 4 and the No. 200 sieve sizes) and 73 percent silt and clay-sized particles (minus No. 200 sieve size).

(2) Plasticity Characteristics. - The results of Atterberg limits determinations on samples of the various materials encountered in Borrow Area A and on samples representative of the materials in Borrow Area B are summarized on Plate 13. The results are grouped according to material type. All of the samples tested plot above the "A" line, indicating a clay consistency. The three groups of samples with liquid limits less than or equal to 50 percent represent materials from Borrow Area A that would be anticipated for use as borrow. The remaining samples with liquid limits greater than 50 percent represent the highly plastic clay stratum encountered near the bottom of most of the borings in Borrow Area A and materials from Borrow Area B.

(3) Natural Water Content. - The results of 22 natural water content tests on samples of materials from Borrow Area A and Borrow Area B are listed in Table B-5 in Appendix B, in Volume II of Design Report, October 1985. The natural water content of 12 samples retrieved from Borrow Area A at depths above the level at which borrow operations are expected to be limited due to excessive water (on the order of 10 feet), as described earlier, ranges between 13 and 29 percent. The natural water content of 7 samples retrieved from greater depths ranges between 29 and 36 percent. The natural water content of materials in Borrow Area B is significantly higher and ranges between 55 and 69 percent for the three samples tested. Comparison of natural water contents of samples of potential borrow material from Borrow Area A, upon which compaction tests were performed, to the optimum water contents indicates that they are within 2 percent of the optimum water content, with one exception. The most plastic sample was 5 percent above optimum water content.

(4) Compaction. - Compaction characteristics of materials anticipated for use from Borrow Area A determined from four tests using currently accepted testing procedures of the American Society for Testing and Materials (ASTM Designation D698-78, Method A), equivalent to the Engineering Manual EM 1110-2-1906 standard compaction test. The results of the tests are summarized on Plate 13. The average maximum dry density of the samples tested is 107.9 pcf and ranges from 100.2 to 116.3 pcf. The average optimum water content of the samples tested is 19.4 percent and ranges from 15.0 to 24.0

percent. The difference in the compaction characteristics of these samples is attributed to variations in plasticity, the material with a higher plasticity index having a lower maximum dry density, and to variations in material gradations. The moist unit weight for compacted, in-place borrow material selected for use in design analyses is 130 pcf.

(5) Shear Strength. - Shear strength properties of materials anticipated for use from Borrow Area A were determined from 16 triaxial compression tests on fabricated samples. Samples believed to represent the weaker of the materials anticipated for use were among those tested. The maximum dry densities and optimum water contents resulting from compaction tests performed on the same materials were used as a basis for fabricating triaxial specimens to dry densities and water contents typical of what will be required during construction. All of the specimens were compacted to 95 percent of maximum dry density at water contents approximately 2 percent above optimum water content.

Eight of the 16 tests were unconsolidated undrained triaxial compression tests. The remaining 8 tests were consolidated undrained tests. The consolidated undrained test samples were consolidated under a range of pressures to encompass anticipated remedial repair loading conditions and were then failed in an undrained condition. Pore pressures were measured during the consolidated undrained tests so that shear strength parameters for both the total stress and effective stress conditions could be determined. The confining pressures on the samples ranged from 5 to 20 psi. The total stress shear strength results of the unconsolidated undrained tests and the total stress and effective stress shear strength results of the consolidated undrained tests for the borrow materials are summarized on two charts on Plate 13 in the form of Mohr-Coulomb strength envelopes.

The design envelopes selected for use in defining soil parameters for stability analyses are also indicated on the two charts on Plate 13. They are based on selecting lower bound envelopes below the test data. The unconsolidated undrained total stress and consolidated undrained total stress and effective stress strength parameters selected for use in design analyses for the borrow material are indicated in the table of design parameters on Plate 13.

(6) Consolidation. - Two consolidation tests were performed on fabricated samples of materials anticipated for use from Borrow Area A in order to evaluate the settlement characteristics of the compacted borrow material. Samples believed to represent the more compressible of the materials anticipated for use were those tested. Both specimens were compacted to 95 percent of maximum dry density at water contents approximately 2 percent above optimum water content. The results of the consolidation tests are summarized on Plate 13 in the form of void ratio versus log of pressure curves. The consolidation parameters selected for use in design analyses are indicated in the table of design parameters on Plate 13.

(7) Permeability. - Permeability characteristics of materials anticipated for use from Borrow Area A were determined from two tests on fabricated samples. One of the samples, a clayey sand, believed to represent the more pervious of the materials anticipated for use, was among those tested. Both specimens were compacted to 95 percent of maximum dry density at water contents approximately 2 percent above optimum water content. As indicated on Plate 13, the two samples had coefficients of permeability (vertical direction of flow) of 1.6×10^{-7} and 2.2×10^{-6} cm/sec in a consolidated state, at a confining pressure of 10 psi. Both of these permeabilities, although an order of magnitude apart, indicate essentially an impervious material. One of the samples, although classified as a sand, contains a great enough percentage of fines to make it essentially impervious. The coefficient of permeability for the compacted, in-place borrow material selected for design is 10^{-6} cm/sec.

20. Soil Design. -

a. General. - This paragraph discusses the remedial repair design developed for the existing levee within the 2.4-mile study area and the design of an alternative cross levee. The various analyses used to develop and evaluate the designs are described, and design plan, profiles, sections, and details are provided.

The project layout plan for the existing levee repair, showing the proposed alignment for the remedial repair and required work in various sections along the existing levee study area, is presented on Plate 14. A profile is provided on Plate 15, and cross sections and details are shown on Plate 16. The project layout plan for the alternative cross levee design, showing the proposed optimal alignment for this structure, is presented on Plate 18. A profile is provided on Plate 19, and cross sections and details for this alternative design are shown on Plate 20.

b. Design Criteria. - The designs developed during this study and presented herein were performed in accordance with Engineering Manual (EM) 1110-2-1913, Design and Construction of Levees dated March 31, 1978. The engineering and design were based on certain criteria established for the subject portion of the Sacramento District, Corps of Engineers' Design Memorandum No. 13, criteria established in the engineering manual referenced above, and other criteria established during this study. The basic design criteria providing the bases for design are listed below:

- Design flood plane at Elevation 18.4 feet (Corps of Engineers datum) along Cache Slough and rising above Elevation 18.4 feet from the junction of Cache Slough and Shag Slough north along Yolo By-Pass at a slope of 0.0114 percent, based on Design Memorandum No. 13.

- Minimum design freeboard of 6 feet along Yolo By-Pass and 4 feet along Cache Slough, based on the original design memorandum.

- Maximum tidal range between Elevation 2.3 feet and Elevation 9.2 feet (Corps of Engineers datum), based on current tidal information for the location of Rio Vista, adjusted for the project site by adding 0.3 feet.

- Minimum levee crown width of 20 feet based on Design Memorandum No. 13.

- Waterside slope no steeper than 3 horizontal to 1 vertical and landside slope no steeper than 2 horizontal to 1 vertical, based on Design Memorandum No. 13, subject to meeting minimum stability criteria.

- Minimum patrol road width of 12 feet based on Design Memorandum No. 13.

- Minimum stability criteria according to Engineering Manual 1110-2-1913, listed below:

Condition	Minimum Required Factor of Safety
End of Construction	1.3
Long Term	1.4
Earthquake	1.0

- Pseudostatic coefficient of 0.10g used to analyze for seismic loading conditions.

- Minimum extent of waterside riprap slope protection up to Elevation 12.0 feet (Corps of Engineers datum) or to the top of a waterside berm, based on Design Memorandum No. 13.

c. Development of Trial Designs. - Several types of design and construction schemes were considered as potential remedial solutions for the problem levee reach. The elimination or further study of these schemes was based on the consideration of foundation and borrow material properties, ground water conditions, constructability, and cost. The feature basic to most all of the schemes is placement of a certain amount of fill in the landside direction of the existing levee in areas where it is deficient in grade and establish a project standard cross section meeting minimum stability criteria. Variations of this basic design concept that were considered are listed below.

- Use of counterweights or stability berms to optimize the required cross section of a uniform slope by more effective placement of resisting weight where it is needed most, thereby minimizing the volume of the required section and its cost.

- Excavation and replacement of weak and compressible foundation soils in conjunction with the landside fill to improve foundation conditions, thereby allowing steeper embankment slopes and reducing the required size of the cross section and its cost.

- Use of staged construction to permit the dissipation of construction pore pressures, resulting in a gain in material strength that would translate to allowable steeper embankment slopes and smaller required volume of the ultimate cross section.

- Use of vertical sand drains in the weak and compressible foundation to increase the rate of consolidation to achieve the same objectives of staged construction or used in conjunction with stage construction.

Other design concepts considered included construction of a floodwall along sections of the existing levee that are deficient in grade to achieve the required freeboard, and the reconstruction of the existing levee to project grade and section using some form of soil reinforcement.

The concept of foundation excavation and replacement was eliminated on the basis of constructability and cost. In order to be effective in improving foundation conditions, this technique would require the removal and replacement of large volumes of material to significant depths due to characteristic broad, deep potential critical failure surfaces in the softer foundation layer. This in itself, prior to construction of the landside fill, would be quite costly. More importantly, excavation to the depths that would be required would be very difficult due to shallow ground water conditions. Landside foundation excavation could also further jeopardize the existing levee stability.

Considering the highly impervious nature of the existing levee fill and foundation materials within the study area and the absence of drainage layers in the compressible foundations, staged construction was eliminated as a viable alternative for optimizing the design section. The maximum time frame desired for construction is two to three years. A relatively small percentage of the ultimate settlement due to loading from a new landside fill and therefore a small percentage of the ultimate gain in strength will have occurred in a two to three year period, as determined from a time-rate-of-settlement estimate. This is discussed in greater detail in the portion of this chapter addressing settlement. (paragraph 20e).

The use of vertical sand drains was considered an option to increase the rate of consolidation in the compressible foundation and possibly make staged construction a more viable alternative with the same objective of minimizing the required size of the design section. However, the lack of any defineable drainage layers in the softer foundation which could be intersected by the sand drains would reduce the effectiveness of a vertical sand drain system and would require closed spacing of the drains for maximum performance. Such a foundation drainage system in itself would be quite costly and, when coupled with the landside fill earthwork cost of a somewhat reduced design cross section, and additional costs associated with staged construction over a number of years, was judged to be less cost-effective than other alternatives and was not studied further. Also, considering the degree of impermeability of the foundation materials, anisotropic effects were judged not to make a significant difference in vertical and horizontal permeability in terms of effective foundation drainage.

The construction of some type of floodwall to achieve additional freeboard is sometimes used, particularly when additional right-of-way can not be obtained for levee enlargement or foundation conditions prohibit an increase in the levee section. In this case, a floodwall was not considered a viable solution primarily due to the history of subsidence and differential settlement and the resulting cost of such a structure designed to withstand such conditions. In addition, the floodwall would only fulfill part of the requirements to bring the levee up to standards. Certain areas would still

require fill to establish the minimum project standard cross section, not to mention satisfying minimum stability criteria. Added fill could cause additional settlement and further stress such a structure.

Because of the anticipated high cost of import fill from Borrow Area A, an alternative to the landside fill design involving the reconstruction of the existing levee to project standards using soil reinforcement techniques was investigated in somewhat greater depth. A concept of partial removal of the existing levee section down to a level controlled by the maximum tide and subsequent reconstruction using the same material and additional borrow as necessary with soil reinforcement was studied. Additional stability would be achieved by the tensile strength of horizontal layers of reinforcement, such as Tensar geogrids, incorporated into the levee section, providing additional resistance to deep-seated potential critical failure surfaces passing up through the levee section from the foundation to the crown, A rough cost comparison or an estimated design of such a reinforcing system using Tensar geogrids and estimated required design of a conventional fill placed on the land side of the existing levee indicated that there would be no significant savings using the soil reinforcement concept. Based on this, and considering that such a technique is not common for levee construction, does not have a lot of performance history, and would have more associated unknowns and uncertainties than a conventional design, the soil reinforcement concept was not considered further.

As a result of the consideration of the various design concepts just discussed, the primary design considered most viable for the repair of the existing levee within the study area consists of a conventional, compacted earth fill placed above the natural ground at a location and in a configuration on the land side of the existing levee to meet minimum stability criteria with a minimum of volume. Various alternative trial design cross sections for this landside fill scheme were thus investigated in depth to develop the required design. Preliminary investigation of alternative trial designs involved the determination, by trial and error, of the location of a landside fill with a project standard crown at design grade in relation to the existing levee and the determination of the required landside slope to satisfy minimum stability criteria. Later refinements to the design involved a variation of this preliminary design using berms to optimize the location of weight distribution for stabiity and thus minimize the required fill volume. Trial and error determination of minimum widths of these berms required to satisfy minimum stabiltiy criteria were made. These trial design alternatives investigated for the existing levee repair are represented by the schematic sections on Figure III-1. The study of various configuarions of the landside fill design was greatly dependent on the selection of shear strength parameters for the foundation materials as is discussed in the next section on stability.

Most of the preceding discussion regarding the consideration of various design and construction schemes for the existing levee repair and the rationale behind the elimination of more detailed investigation into certain of these schemes is also applicable to the development of the cross levee design. Various alternative trial design cross sections of a conventional, compacted earth fill were investigated to develop the required cross levee design. Preliminary investigation of alternative trial designs involved the trial and error determination of the maximum allowable slopes of an embankment with a project standard crown at design grade to meet minimum

stability criteria. As for the existing levee repair design, later refinements to the cross levee design involved the incorporation of stability berms into the design cross section. The trial design alternatives investigated for the cross levee are represented by the schematic sections on Figure III-2.

d. Stability. - The levee embankment and its foundation are subjected to a number of forces which are critical under certain conditions. The stability of the levee depends on the action of these forces. Forces that the levee embankment and foundation must resist for adequate stability include the weight of embankment material, unbalanced external water forces, and internal seepage forces. Transient loading conditions, such as those imposed during an earthquake, also may affect levee stability. Resistance of these forces by the inherent shear strength of the earth materials comprising the levee embankment and by the natural foundation materials will provide a certain level of stability for the levee.

The performance of the levee and foundation under these forces and critical conditions is determined by performance stability anlyses. A description of the stability anlyses performed to develop and confirm the adequacy of the existing levee repair and cross levee designs, and the results obtained are presented in the following sections.

(1) Description of Stability Analyses. - Stability analyses were performed for various alternative trial cross sections for the existing levee repair and cross levee designs. The analyses were performed for the waterside and landside slopes of critical cross section in accordance with Engineering Manual 1110-2-1913. Conventional limit equilibrium methods were used to determine factors of safety against sliding. Seismic loading conditions were approximated by pseudostatic analyses. Design parameters consisting of the geometry of the levee embankment and foundation, and the unit weight and shear strength properties of the levee embankment and foundation materials were the bases of the analyses. Several stability conditions were analyzed to obtain the minimum factors of safety during these conditions over the life of the levee system. Computer analyses assisted in defining minimum safety factors and allowed numerous cases to be studied. A detailed discussion of the various aspects of the stability analyses follows.

(a) Design Criteria. - The existing levee repair and cross levee are designed to meet minimum stability criteria in accordance with Engineering Manual 1110-2-1913.

(b) Selection of Cross Section for Analyses. - Initial stability analyses were performed on the existing levee itself. The existing levee embankment and foundation cross section used for the analyses is shown on Plate 17. The bases for the selected cross section geometry are listed below:

- Waterside slope of 3 horizontal to 1 vertical and landside slope of 2.5 horizontal to 1 vertical, based on a study of the existing levee topography within the study area and a review of surveyed cross sections, and the selection of the steepest general overall slopes observed. (Some localized steeper slopes exist.)

- Waterside channel slope (below low water level) of 5 horizontal to 1 vertical, based on a review of available cross sections from soundings.

- Crown width of 20 feet.

- Levee embankment height of 20 feet, based on a comparison of the existing levee crown grade in areas currently exhibiting instability and subsidence to the natural ground elevation on the landside from available topography and based on the estimated foundation level from exploratory drilling through the existing levee and examination of samples. The selection of this height generally representing subsided areas is considered conservative considering that final foundation strength parameters were back-calculated for a given factor of safety, as discussed in greater detail in the section discussing the selection of design parameters.

- Depth of softer foundation beneath the existing levee of 20 feet, based on findings from field vane shear testing, exploratory drilling, and examination of samples during the existing levees investigation.

- Assumed boundary between foundation materials designated "softer foundation beneath existing levee" and "softer foundation beyond toe of existing levee", based on an estimated location in the foundation at which 50 to 75 percent of the maximum vertical stress due to the maximum load beneath the levee crown would be experienced, which is considered conservative.

- Water level in relation to the selected levee embankment and foundation cross section corresponding to a low tide.

Numerous cross sections with varied landside locations and configurations were used in the stability analyses for the existing levee repair. The optimal design section satisfying minimum stability criteria was found by trial and error variation of the landside position of the added levee in relation to the existing levee, embankment slopes, and berm widths. The final design of the existing levee repair section used for stability analyses is shown on Plate 17. The bases for the cross section geometry analyzed are listed below:

- Existing levee embankment and foundation geometry as previously described with the exception of the landside embankment slope.

- Existing levee landside slope of 6 horizontal to 1 vertical, selected to represent the flattest general overall slope observed within the study area, based on a study of the existing levee topography and a review of surveyed cross sections. Flattening of the existing levee landside slope for analysis of a landside fill recognizes that the existing levee fill is assigned lower shear strength parameters than borrow material for the new landside fill and thus represents a more critical condition.

- Intermediate slopes between crown and berm and natural ground of 3 horizontal to 1 vertical on the water side and 2.5 horizontal to 1 vertical on the land side to be consistent with existing levee slopes and within minimum project standards.

- Crown width of 20 feet as required by project standards.

- Landside fill embankment height 7 feet above the existing levee embankment height of 20 feet, based on a maximum current deficiency in grade of 4 feet below design grade within the study area and an estimated maximum overbuild requirement of 3 feet (paragraph 20e).

o Waterside berm height of 10 feet to be above high tide.

As for the existing levee repair, numerous cross sections with varied configurations were used in the cross levee stability analyses. The optimal design section satisfying minimum stability criteria was found by trial and error variation of embankment slopes and berm widths. The final design cross levee section used for stability analyses is shown on Plate 21. The bases for the cross section geometry analyzed are listed below:

o Intermediate slopes between crown and berm and natural ground of 3 horizontal to 1 vertical to be within minimum project standards.

o Crown width of 20 feet as required by project standards.

o Levee embankment height of 25 feet, based on a comparison of project design grade to the natural ground elevation from available topography along alternative cross levee alignments plus an estimated maximum overbuild requirement of 3 feet (paragraph 20e).

o Depth of softer foundation beneath the cross levee of 20 feet, based on findings from field vane shear testing and exploratory drilling in the foundation beneath the existing levee and in the island interior during field investigations, and from examination of samples during laboratory investigations.

o Shallow ground water conditions, conservatively assumed at the natural ground surface.

(c) Selection of Design Parameters. Shear strength parameters for use in stability analyses were determined in accordance with the criteria in Engineering Manual 1110-2-1913, summarized below for this study:

Condition	Shear Strength
End of Construction	Q
Long Term	S where R
	$\frac{R+S}{2}$ where R S
Earthquake	same as Long Term

where:

Q = unconsolidated undrained shear strength (total stress)
R = consolidated undrained shear strength (total stress)
S = consolidated drained shear strength (effective stress)

As described in Chapters III, pore pressure measurements during consolidated undrained triaxial tests allowed the determination of shear strength for the effective stress condition. This was substituted for the S strength in the above criteria (R, the consolidated undrained effective stress shear strength is equivalent to S, the consolidated drained effective stress shear strength).

The engineering properties of levee embankment and foundation materials based on the results of field and laboratory testing during the existing levees and borrow investigations were used to develop soil parameters for use in initial stability analyses. A detailed discussion of the field and laboratory tests results and the selection of engineering properties for design is presented in Chapter III. As a result of the outcome of initial stability analyses of the existing levee, in situ undrained shear strengths of the foundation materials were reduced for final design analyses.

Initial stability analyses using in situ undrained shear strengths of levee embankment and foundation materials, selected purely on the basis of field and laboratory test results (see table of design parameters on Plate 11), gave minimum factors of safety for both the waterside and landside slopes of the selected existing levee section on the order 1.4. The computed factors of safety were higher than anticipated, considering the historical performance and current state of distress along some sections of the existing levee within the study area, and also considering that the selected design parameters, including geometry, were believed most conservative given the known data.

Prior to re-evaluating the selected strength parameters, variations of the selected existing levee cross section geometry were investigated. Stability analyses for sections with steeper levee embankment slopes and with cracks in the upper portion of the levee embankment indicated that the computed minimum factors of safety were not very sensitive to these variations. This is not surprising considering that the stability is mainly dependent on the strength of the softer foundation beneath the existing levee because of the characteristic broad, deep potential critical failure surfaces being modeled.

As a result of findings from the initial analyses, the approach taken was to reassign the selected in situ undrained shear strengths of the foundation materials proportionately lower values to result in computed minimum factors of safety for the existing levee embankment slopes closer to unity. The bases for this approach are listed below:

- The selection of in situ undrained shear strength parameters for the foundation materials was most difficult, given the scatter in the test data and the limited data base from which the strengths were selected.

- The long history of subsidence and stability problems and the inability to raise the existing levee to project grade with relatively small heights of additional fill without inducing continuing failures, and the observation of areas currently exhibiting distress suggests that there are sections of the existing levee within the study area currently failing or in a state of incipient failure.

- For unstaged construction of a new fill on the land side of the existing levee or a new cross levee, the end of construction stability condition controls the configuration of the design cross section, and the in situ undrained shear strength of the foundation materials provides the basis for foundation shear strengths used in the end of construction stability analyses.

Originally selected in situ undrained shear strength parameters for the foundation materials were proportionately reduced to result in minimum computed factors of safety of 1.1 for the waterside and landside slopes of the selected existing levee section. The in situ undrained shear strength of the foundation material designated "softer foundation beneath existing levee" was reduced from 600 psf to 450 psf. These reduced strength parameters were used in all other stability analyses for final design of the existing levee repair and cross levee.

Based on the design parameters selected from field and laboratory investigations, adjustments made to these parameters during preliminary design as just described, and the criteria for using these parameters in stability analyses according to Engineering Manual 1110-2-1913, the soil parameters used for final design stability analyses are summarized in Table III-5. The soil parameters are also indicated on Plates 17 and 21 with the stability analyses results for the existing levee repair and cross levee designs, respectively. The final design shear strength parameters used for the various conditions analyzed for the various levee embankment fill and foundation materials are also presented on Figures III-3 through III-6 in the form of Mohr-Coulomb strength envelopes.

The impact that the selected final design foundation shear strength paramenters had on the existing levee repair design is seen by comparison of the two schematic sections on Figure III-1. Preliminary trial designs, which were based on originally selected foundation strength parameters, considered a landside fill with no changes to the existing levee section. It was determined that stabilization of the existing levee waterside slope was not necessary in conjunction with the landside fill to satisfy minimum stability criteria, as long as the landside fill with added height was placed a sufficient distance landward. However, after establishing final design foundation shear strength parameters and performing additional stability analyses and volume comparisons for alternative cross sections, it became evident that degrading of the existing levee to form a waterside berm for the new landside fill would provide the most desirable design. The reduced final design foundation strength parameters required the stabilization of the existing levee waterside slope. Creation of the waterside berm stabilizes the existing levee section by unloading its foundation, and material generated from existing levee degrading could be used in the new landside fill.

(d) Conditions Analyzed. - Several slope stability cases for both the waterside and landside embankment slopes of the existing levee repair and cross levee designs were analyzed. The conditions analyzed are listed below:

- End of construction - waterside and landside slopes.
- Long Term - waterside slope: analyses with water level corresponding to a low tide.
- Long Term - landside slope: analyses with water level corresponding to the design flood plane.

The end of construction condition was expected to control in regard to selection of the minimum required design cross section and was therefore analyzed first. A total stress analysis was used to analyze this condition

using shear strengths. By the use of these parameters, the analysis accounts for excess pore pressures that would be present until the soil has time to consolidate and drain after being loaded.

Effective stress analyses were used to analyze long term conditions using shear strength parameters based on the average of total stress and effective stress envelopes from consolidated undrained triaxial and direct shear tests. The use of strengths midway between the total and effective stress envelopes is in accordance with Engineering Manual 1110-2-1913. The effective stress analysis assumes pore pressures to be in equilibrium with no excess pore pressures present. Pore pressures used in the stability analyses for the long term conditions were conservatively estimated by the assumption of vertical equipotential lines below the phreatic surface within the levee embankment. Pore pressures within the levee embankment and foundation were taken as being equal to a head of water with a vertical distance between the point of interest and the water level or phreatic surface within the levee. The configuration of the assumed phreatic surfaces for the long term conditions analyzed are shown on Plates 17 and 21 for the existing levee repair and cross levee designs, respectively. The phreatic surfaces used in the landside slope stability analyses, with a water level against the waterside slope corresponding to the design flood plane, are considered conservative, since only a very small portion of the water side of the levee embankment is likely to become saturated from a flood condition. This is discussed in more detail in the following paragraph. The long term conditions were analyzed for both static and pseudostatic (earthquake) loading conditions. Seismic loading conditions were approximated by using a pseudostatic coefficient of 0.10 g for the long term stability analyses. An earthquake load equal to 10 percent of the total weight of soil in any given soil slice being analyzed was applied as a static horizontal force acting in the direction of instability at the center of the slice. Horizontal pseudostatic forces were not applied to water against the waterside slope, which was assigned zero shear strength.

Because of the highly impervious nature of the existing levee embankment fill and anticipated borrow materials, a saturation front would advance into the levee embankment section from the waterside slope only a very small distance during the anticipated time that water may remain at a given flood level. Because only a very small portion of the water side of the levee embankment is likely to become saturated, a sudden drawdown condition would not exist following a rapidly receding flood stage. Therefore, a sudden drawdown condition was not analyzed. A check for shallow sliding or sloughing using infinite slope analyses indicated factors of safety exceeding the minimum criteria.

(e) Method of Analyses. - Conventional methods of limit equilibrium stability analyses to determine factors of safety against sliding using circular arc failure surfaces formed the basis of stability studies. For the approach taken of assigning a uniform lower bound strength to the entire softer foundation layer, which is conservative, the circular arc failure surfaces used for the stability analyses is appropriate. The waterside and landside slopes for the various conditions previously discussed were computer-analyzed for circular arc failure modes using both the Fellenius method of slices and Bishop's modified method. These methods incorporate, as basic input data, the geometry of the levee embankment slope and internal zones and the geometry of the levee foundation, unit weight and shear strength properties of the levee embankment and foundation materials, and the

distribution of boundary and internal water forces. After a failure surface has been assumed, the soil mass above the sliding surface is divided into a series of vertical slices. Forces acting on each slice include the earth pressures on its sides, water pressures on its sides and bottom, effective earth pressure with associated friction acting on the assumed sliding surface, and cohesion along the sliding surface. Various trial failure surfaces are analyzed until a minimum factor of safety is obtained for the case being studied.

The Fellenius method of slices is based on overall static moment equilibrium but does not consider the influence of side forces between slices. The factor of safety is calculated by comparing the moment of resistance offered by the cohesion and friction along the sliding surface to the moment of the driving force about the center of the assumed circular arc failure surface. The Bishop's modified method is a slightly more rigorous approach in which vertical equilibrium of the individual slices and overall moment equilibrium are satisfied. Side forces are included in the Bishop's analysis by using the simplifying assumption that they act only in a horizontal direction. Like the Fellenius method, factors of safety are obtained by comparing the resisting and driving moments.

These two computational methods were performed by computer analyses. The computer program STABR, developed at the University of California at Berkeley in 1972, was used to perform the stability analyses. The program performed automatic searches of different potential failure arcs to determine the most critical surface having the lowest factor of safety for the condition being analyzed.

(2) Results of Stability Analyses. The stability analyses results for the existing levee and the results of the critical cases for the various conditions studied for the existing levee repair final design are presented on Plate 17. The stability analyses results of the critical cases for the various conditions studied for the cross levee final design are presented on Plate 21. The results of end of construction, long term and earthquake waterside slope, and long term and earthquake landside slope stability analyses are shown on separate cross sections. Each of the cross sections show the locations of various levee embankment and foundation materials, assumed water levels and phreatic surfaces, and the critical circles for the various conditions analyzed with the minimum factors of safety computed using Bishop's modified method indicated. As noted earlier, the end of construction condition controls the design in all cases.

e. Settlement. - Nearly all of the settlement that will result from construction of a new fill on the land side of the existing levee or from construction of a cross levee across virgin ground will be due to consolidation in the soft foundation layer identified by field and laboratory investigations. Settlements within the existing levee or the newly placed fill will be negligible by comparison. An estimate of the maximum anticipated settlement was made for the purpose of designing overbuild into the existing levee repair and cross levee designs. Required overbuild was also accounted for in the stability analyses described in the preceeding paragraphs particularly because of the apparent sensitivity of stability to relatively small additional heights of fill.

A significant portion of the maximum section of the existing levee repair design will be over native ground near the landside toe of the existing levee, and a new cross levee would obviously be founded entirely on virgin ground. Therefore, the estimated maximum settlement was based on the application of a loading created by the maximum design section beneath the levee crown, to the previously unloaded foundation. No reduction of loading from stress distribution in the foundation was used due to the relatively shallow depth of soft foundation in relation to the loading magnitude and extent of the loaded area. The settlement estimate was based on soil properties determined from consolidation testing on the softest undisturbed samples retrieved from the foundation at the landside toe of the existing levee, outside significant influence of existing leveel loading. These consolidation properties were applied to the entire 20-foot soft foundation layer selected for design analyses to arrive at an estimated maximum settlement, which is believed conservative.

The maximum estimated settlement computed, upon which overbuild requirements are based, is on the order of 3 feet and was based on the following assumptions and data:

o Corrected field void ratio versus log of pressure curve for a consolidation test on foundation material at the landside toe of the existing levee (hole 7F-3A-85, sample UD-5, depth 16.0 feet) with the following estimated properties:

e_o, initial void ratio = 3.45
P_c, preconsolidation pressure = 1,700 psf
P_o, effective overburden pressure = 680 psf
$C_{c\ oc}$, compression index in overconsolidated range = 0.28
$C_{c\ nc}$, compression index in normally consolidated range = 1.7

(The laboratory void ratio versus log of pressure curve is shown on Plate 11.)

o Layer thickness of 20 feet.

o Average moist unit weight of foundation material of 85 pcf.

o Ground water table at natural ground surface.

oo Applied load from approximately 27 feet of fill with an average unit weight of 130 pcf, or 3,500 psf.

The estimated settlement was computed according to the following formula:

$$\Delta H = \frac{H}{1+e_o}\left(C_{c\ oc} \log \frac{P_c}{P_o} + C_{c\ nc} \log \frac{P+\Delta P}{P_c}\right)$$

where: ΔH = settlement, feet
H = layer thickness, feet
e_o = initial void ratio
$C_{c\ oc}$ = compression index in overconsolidated range

C_c nc = compression index in normally consolidated range
P_c= preconsolidation pressure of test sample, psf
P_o= effective overburden pressure of test sample, psf
P = effective overburden pressure at midpoint of layer, psf
ΔP = applied load, psf

The above formula includes the effect of preconsolidation, sometimes termed the P_c - effect, which was estimated and included in the analysis.

Although judged to be neglible, an estimate was made of the maximum anticipated settlement within the embankment fill for the existing levee repair and cross levee designs to confirm this. Based on the results of consolidation testing of borrow materials anticipated for use, fabricated to densities that will be required as a minimum during construction, the estimated maximum settlement contributed by the new fill itself is on the order of one percent of the embankment height.

Immediate settlements associated with shear strain and lateral yield in the foundation clay beneath the loaded area should be minimized by the design cross section configurations with berms. Any immediate settlements that do occur would be compensated for by placement of additional fill material during construction. Based primarily on the site condition that a relatively shallow compressible layer will be subject to a significant load such that the ratio of the added pressure to the original effective overburden pressure is high, secondary compression was judged not to be a major contributing component of total settlement.

One of the trial design alternatives included the consideration of staged construction in order to optimize the required design cross section and minimize fill volume. In evaluating whether staged construction would be a viable and realistic approach, time rate of settlement was studied. It was concluded that very little foundation material strength gain due to consolidation would be realized during a reasonable period of time for staged construction. For the soft, previously unloaded foundation layer, which would exist beneath the existing levee repair and cross levee sections, the estimated time at which would exist beneath the existing levee repair and cross levee sections, the estimated time at which 25 percent consolidation would be complete is on the order of 3 years. The estimated time at which 90 percent consolidation would be complete is on the order of 50 years. These estimates were based on the following assumptions and data:

- Coefficient of consolidation of 2×10^{-4} cm^2/sec, based on consolidation testing on foundation material at the landside toe of the existing levee (hole 7F-3A-85, sample UD-5, depth 16.0 feet.)

- Layer of thickness of 20 feet, assumed drained at the surface.

f. <u>Seepage</u>. - Based on the findings from field and laboratory investigations, seepage was determined not to require design consideration from either the standpoint of foundation underseepage or embankment seepage causing the development of excess hydrostatic pressures or piping. The existing levee embankment and foundation materials are highly impervious in nature. Some sandy lenses were encountered at depths in the foundation greater than 20 feet within the study area. However, they are generally composed of clayey sand materials that by nature are fairly impervious

themselves and are at depths that make them of no consequence to design. The borrow materials anticipated for use are also of a highly impervious nature. The most pervious potential borrow material encountered, a clayey sand, was found to contain a great enough percentage of fines to render it essentially impervious.

g. Slope Protection. - As shown on Plates 14 and 15, the existing levee repair design calls for riprap along the entire waterside slope within the 2.4-mile study area. In certain reaches within the study area, wave action in the tidal range has caused sloughing and local oversteepening of existing levee slopes. The installation of riprap slope protection would remedy this condition. In some reaches, mainly along Cache Slough, riprap has already been placed. The design requires riprap only where it does not already exist. As indicated on Plate 16, riprap is to be extended above the tidal range up to Elevation 12.0 feet (Corps of Engineers datum), based on previous requirements established in Design Memorandum No. 13, for reaches of levee where only minor fill and crown shaping work is called for. In reaches where a waterside berm would be created by degrading the top of the existing levee, riprap is to be extended up to the top of the berm, which is also above the tidal range. As shown on Plates 18, 19, and 20, the cross levee design calls for riprap along its south slope and is to be extended up to the top of the berm. The riprap design calls for a minimum 15-inch thick layer of dumped riprap. The riprap could be quarry rock or cobbles and should be relatively fresh, hard, and durable material. SPK-Geotech Branch is looking into the locations for quarries under the SPD directive. The cost estimates presented in the next chapter provide for hydroseeding for erosion protection of the remaining waterside and landside levee slopes not to receive riprap.

h. Instrumentation. - Instrumentation for the existing levee repair and alternative cross levee designs consists of a series of settlement monuments for the purpose of monitoring levee embankment and foundation settlements and displacements after construction. Proposed settlement monument locations are provided on Plate 14 for the existing levee repair design, and on Plate 18 for the cross levee design. The selected locations were based on providing monuments at regular intervals along the design alignment, at locations with a history of instability and subsidence and currently exhibiting distress, and at locations currently most deficient in levee crown grade. In addition to locations along the levee crown, monuments on the waterside and landside berms are proposed to allow monitoring of lateral movements.

Initial elevations and coordinates of the settlement monuments should be established immediately after installation, and survey readings of the monuments and evaluations of the data should be made periodically. Accurate records of the settlement monitoring should be kept up to date.

The installation of piezometers for the existing levee repair and cross levee designs was not considered necessary, since the developed designs do not require staging, and the designs are based on end-of-construction conditions where excess pore pressures are accounted for in the analyses.

i. Selection and Layout of Final Design. - The layout, profile, and cross sections and details of the existing levee repair final design are presented on Plates 14, 15, and 16, respectively. The layout, profile, and cross sections and details of the selected alternative cross levee final design are presented on Plates 18, 19, and 20, respectively. The design

layout for the existing levee repair was not only a product of the analyses described earlier in this chapter, but was also based on a comparison of the current state of the existing levee over various reaches within the study area to required minimum project standards. Figure III-7 identifies sections of the existing levee within the study area that are currently deficient in grade, based on survey data, and the proposed type of repair work for various selected sections. Table III-6 provides detailed information regarding the magnitude of existing grade defieciencies for the sections identified on Figure III-7.

After careful consideration and study of the degree of deficiency in grade that the existing levee crown has over various sections within the study area and consideration of areas that historically and currently exhibit the most distress, two basic conditions were identified:

- o Areas along the existing levee within the study area where only minor amounts of fill, on the order of less than one foot at the crown, and minor shaping of the existing crown would be required to bring the levee section within project standards.

- o Areas along the existing levee within the study area where a significant landside fill would be required to provide a project standard section at design grade.

In addition, certain reaches of the existing levee within the study area are already at or above design grade and have a cross section meeting project standards.

As a result, the two types of work proposed for the existing levee repair design, indicated on Figure III-7 and shown for the design on Plates 14, 15, and 16, were selected. The bases for the selection of the existing levee sections judged only to require minor fill and crown shaping are listed below:

- o Areas with existing crown elevations near or already above the project design grade that would require only minor fill, on the order of less than one foot measured at the crown, to raise the crown to design grade, and where a project standard section could be achieved with minor crown shaping.

- o Areas that have historically exhibited generally better performance than the major problem areas.

The landside fill design would be applied to all other areas.

Of course, the landside fill design, based on the estimated weakest foundation conditions, could be uniformly applied to the entire 2.4-mile reach of levee under investigation. Considering the length of time the levees have been stabilizing since the last remedial repair and upgrade construction in 1980, their current condition relative to project standards, and the anticipated high cost of import fill, however, it was considered prudent to identify in greater detail areas where the basic design of a significant landside fill is not considered justified.

TABLE III-5

SOIL PARAMETERS USED IN STABILITY ANALYSES

		Shear Strength			
		End of Construction		Long Term and Earthquake	
Material[1] Designation	Unit Weight, pcf	Cohesion, psf	Friction Angle, degrees	Cohesion, psf	Friction Angle, degrees
1A	110	800	0	200	20.5
1B[3]	130	1,260	12	240	22.25
2A	95	450	0	200	16
2B	85	300	0	200	16
3	125	---See Footnote 2---			

1 1A - Existing levee fill.
1B - Borrow material (see footnote 3).
2A - Softer foundation beneath existing levee (loaded).
2B - Softer foundation beyond toe of existing levee (unloaded).
3 - Stiffer foundation.

2 Because of the significantly greater strength in the stiffer foundation, stability analyses were performed such that potential failure surfaces remain within the softer foundation and do not pass through the underlying stiffer foundation. Therefore, identification of shear strength parameters for the stiffer foundation for use in stability analyses is not necessary.

3 The shear strength parameters of borrow material selected for stability analyses are based on the borrow material being derived from potential Borrow Area A.

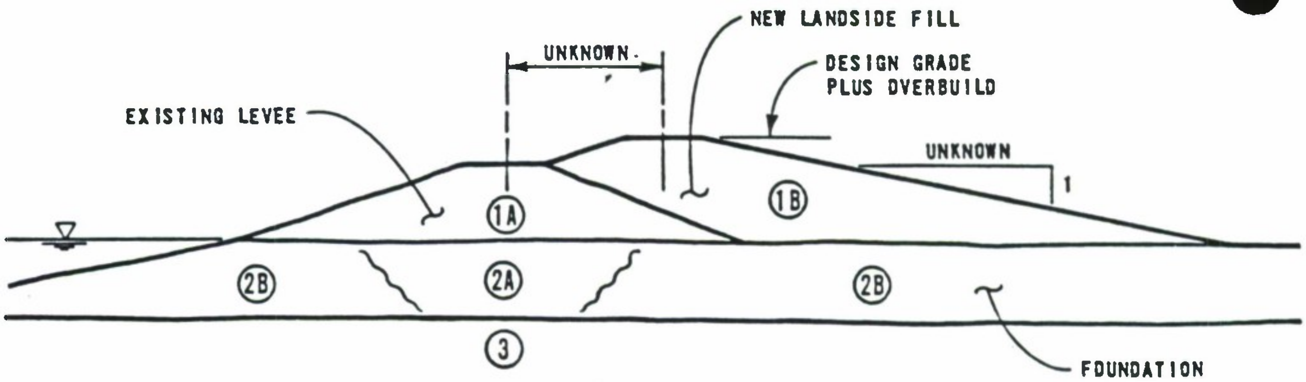
TABLE III-6

EXISTING LEVEE GRADE DEFICIENCIES

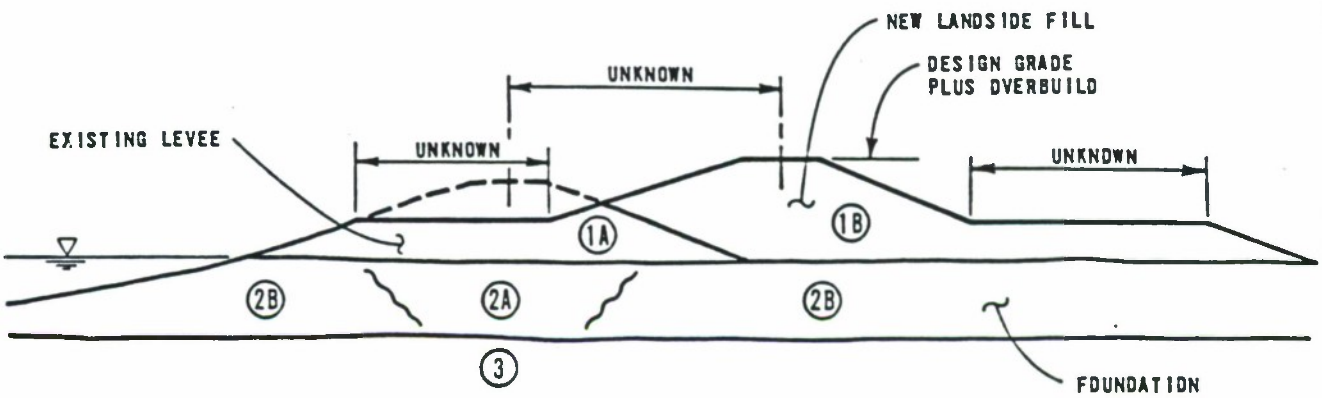
Area Designation [1]	Approximate Traverse Stationing [2]	Design Grade Elevation, feet [3]	Grade Deficiency feet [4]
1	29+70 to 31+10	25.0	0.1
2	35+80 to 43+90	24.9	0.2 to 0.4
3	47+10 to 49+90	24.8	1.5
4	52+80 to 56+90	24.7	1.9 to 2.2
5	58+30 to 61+40	24.7	0.5 to 0.8
6	70+30 to 82+74	24.4 to 24.5	2.5 to 4.1
7	82+74 to 86+00	22.4	0.9 to 1.6
8	88+50 to 91+40	22.4	1.2
9	92+20 to 105+00	22.4	0.1 to 2.6
10	106+80 to 129+30	22.4	0.3 to 2.7
11	146+40 to 147+50	22.4	0.7

1 Refer to Figure 3-7.
2 Refer to Plate 2 for traverse alignment data.
3 Corps of Engineers datum.
4 Range of grade deficiencies based on surveyed spot elevations along the existing levee crown.

154W



SCHEMATIC SECTION
PRELIMINARY TRIAL DESIGN SECTIONS
NOT TO SCALE



SCHEMATIC SECTION
REFINED TRIAL DESIGN SECTIONS
NOT TO SCALE

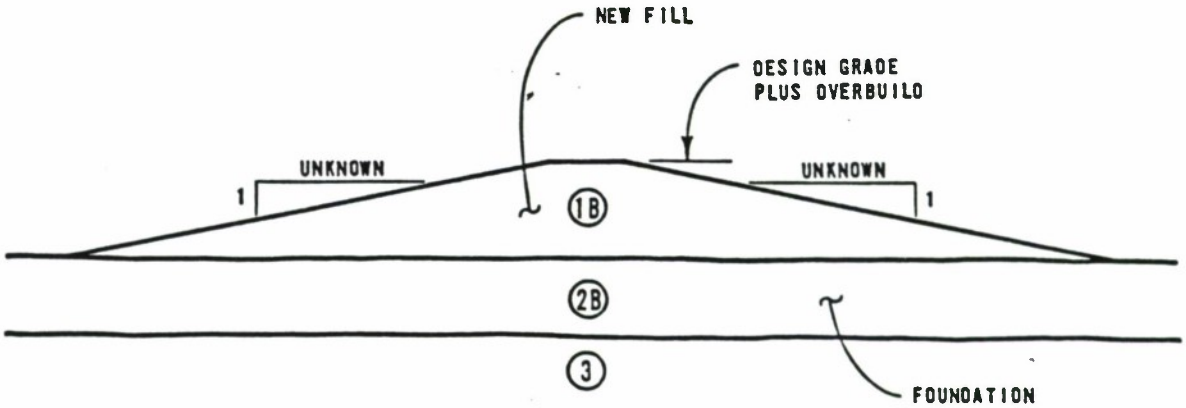
MATERIAL	DESCRIPTION
1A	FILL - EXISTING LEVEE
1B	FILL - BORROW
2A	SOFTER FOUNDATION - BENEATH EXISTING LEVEE
2B	SOFTER FOUNDATION - BEYOND TOE OF EXISTING LEVEE
3	STIFFER FOUNDATION

EXISTING LEVEE REPAIR
TRIAL DESIGN ALTERNATIVES

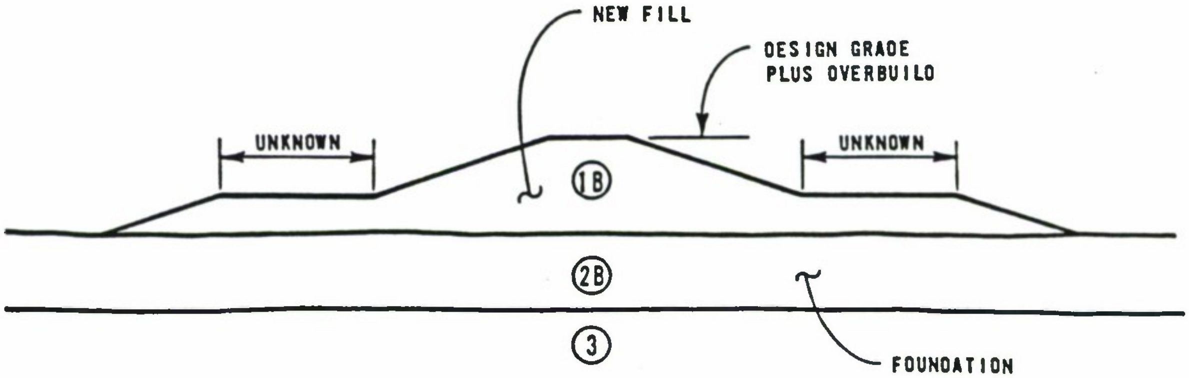
CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
SOLANO COUNTY, CALIFORNIA

FIGURE III-1

154W



SCHEMATIC SECTION
PRELIMINARY TRIAL DESIGN SECTIONS
NOT TO SCALE



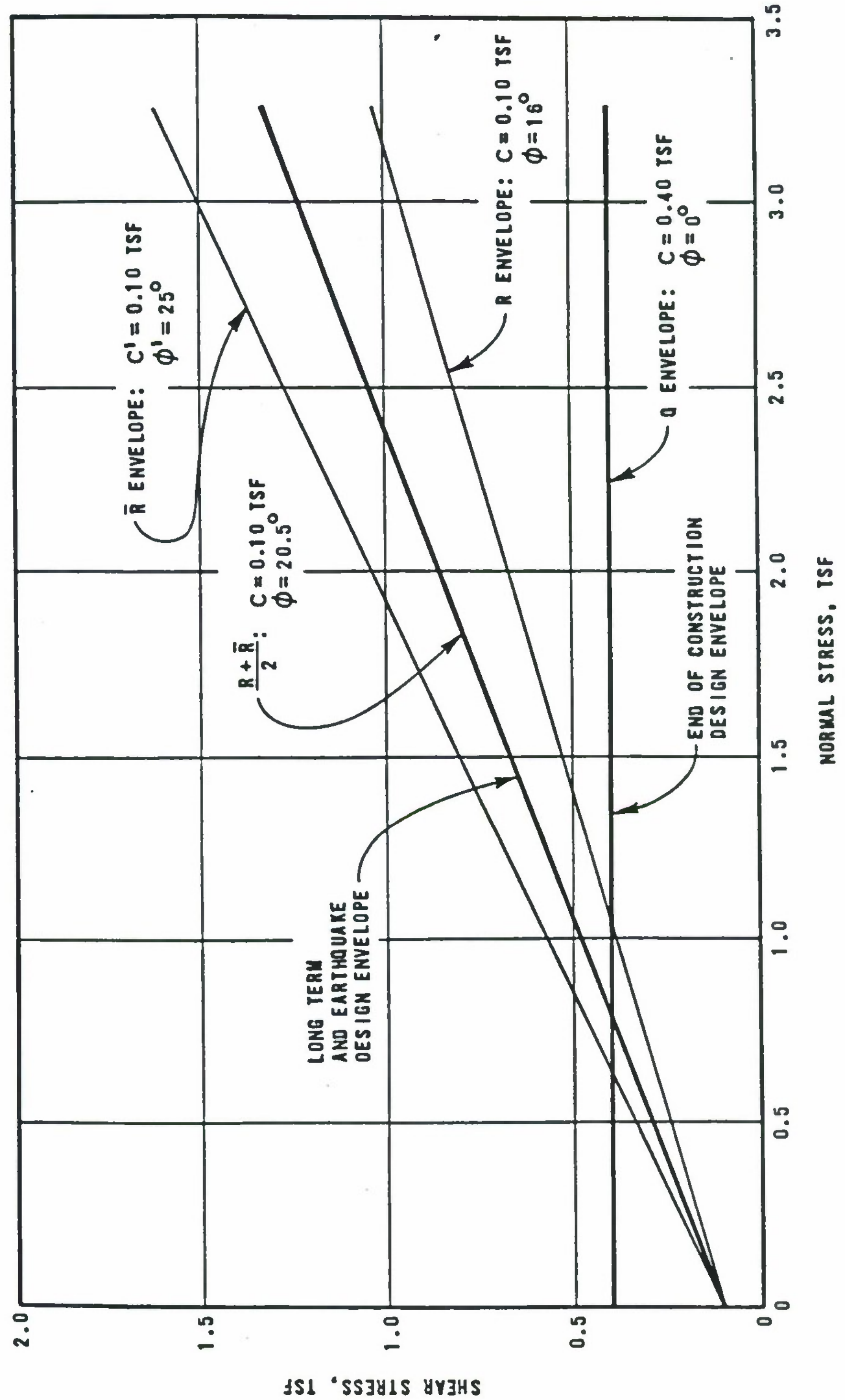
SCHEMATIC SECTION
REFINED TRIAL DESIGN SECTIONS
NOT TO SCALE

MATERIAL	DESCRIPTION
1B	FILL - BORROW
2B	SOFTER FOUNDATION - BEYOND TOE OF EXISTING LEVEE
3	STIFFER FOUNDATION

CROSS LEVEE
TRIAL DESIGN ALTERNATIVES

CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
SOLANO COUNTY, CALIFORNIA

FIGURE III-2



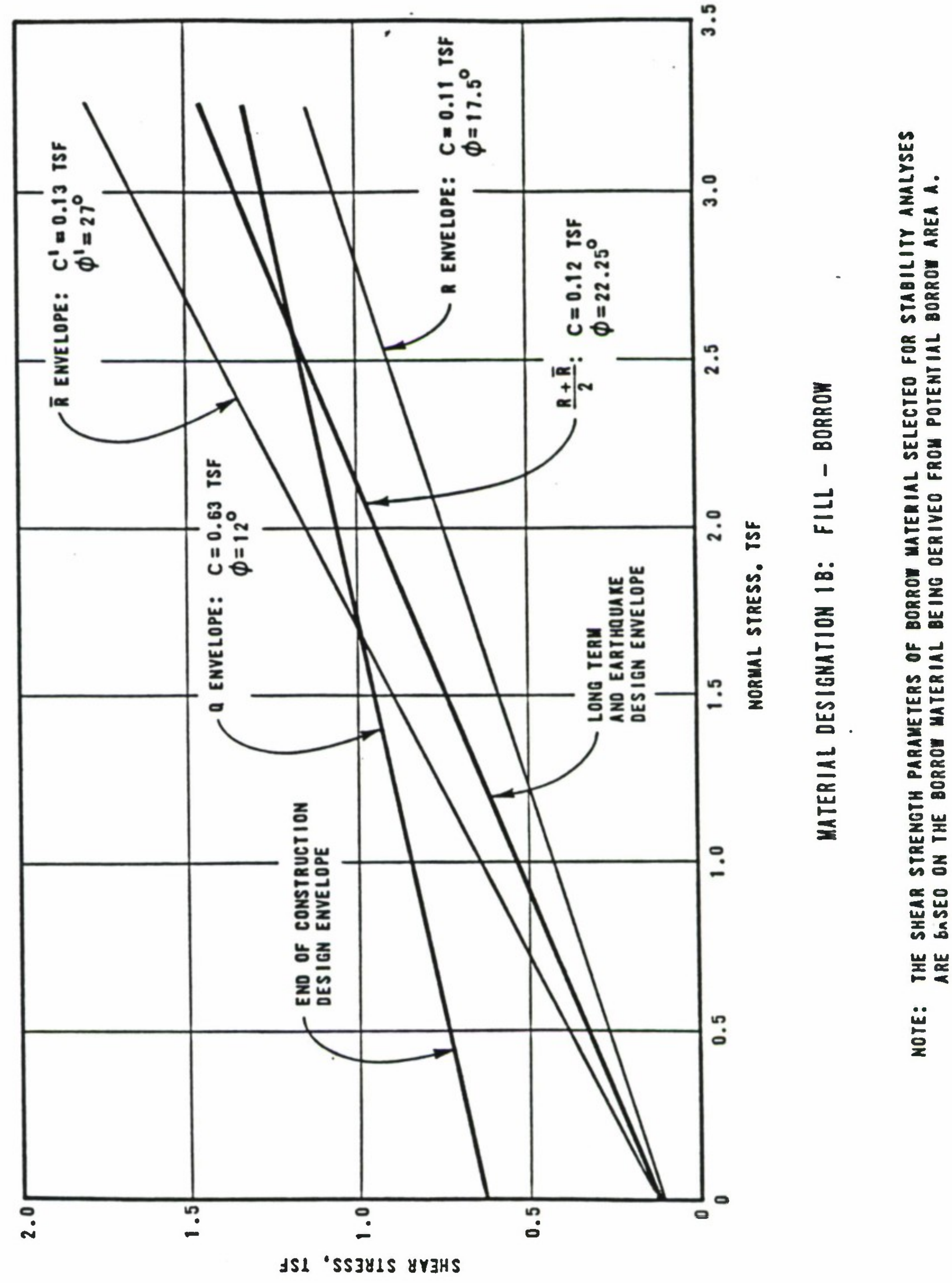
MATERIAL DESIGNATION 1A: FILL - EXISTING LEVEE

EXISTING LEVEE FILL
STABILITY ANALYSIS SHEAR STRENGTH PARAMETERS

CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
SOLANO COUNTY, CALIFORNIA

FIGURE III-3

154W

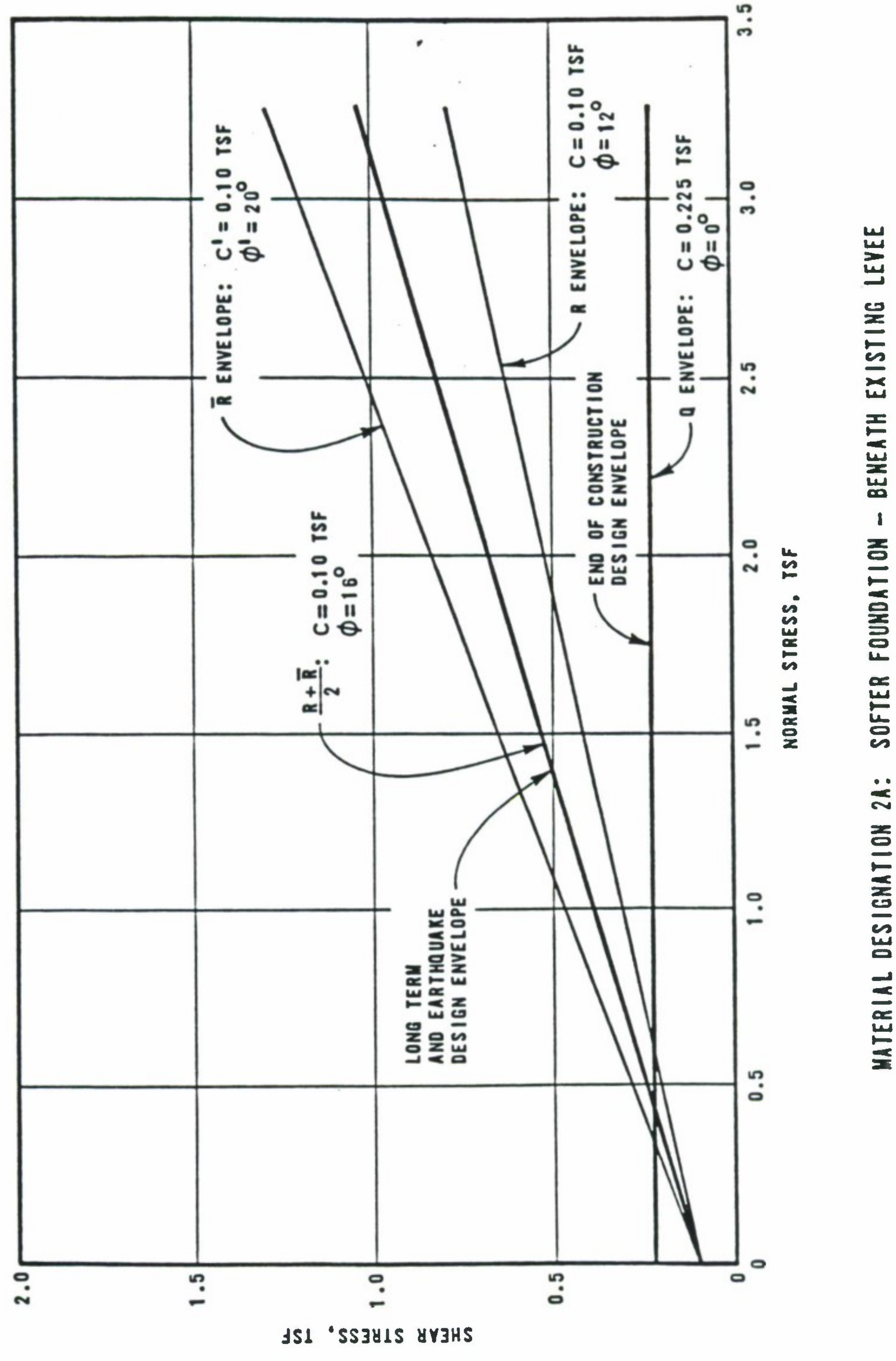


BORROW MATERIAL
STABILITY ANALYSIS SHEAR STRENGTH PARAMETERS

CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
SOLANO COUNTY, CALIFORNIA

FIGURE III-4

154W

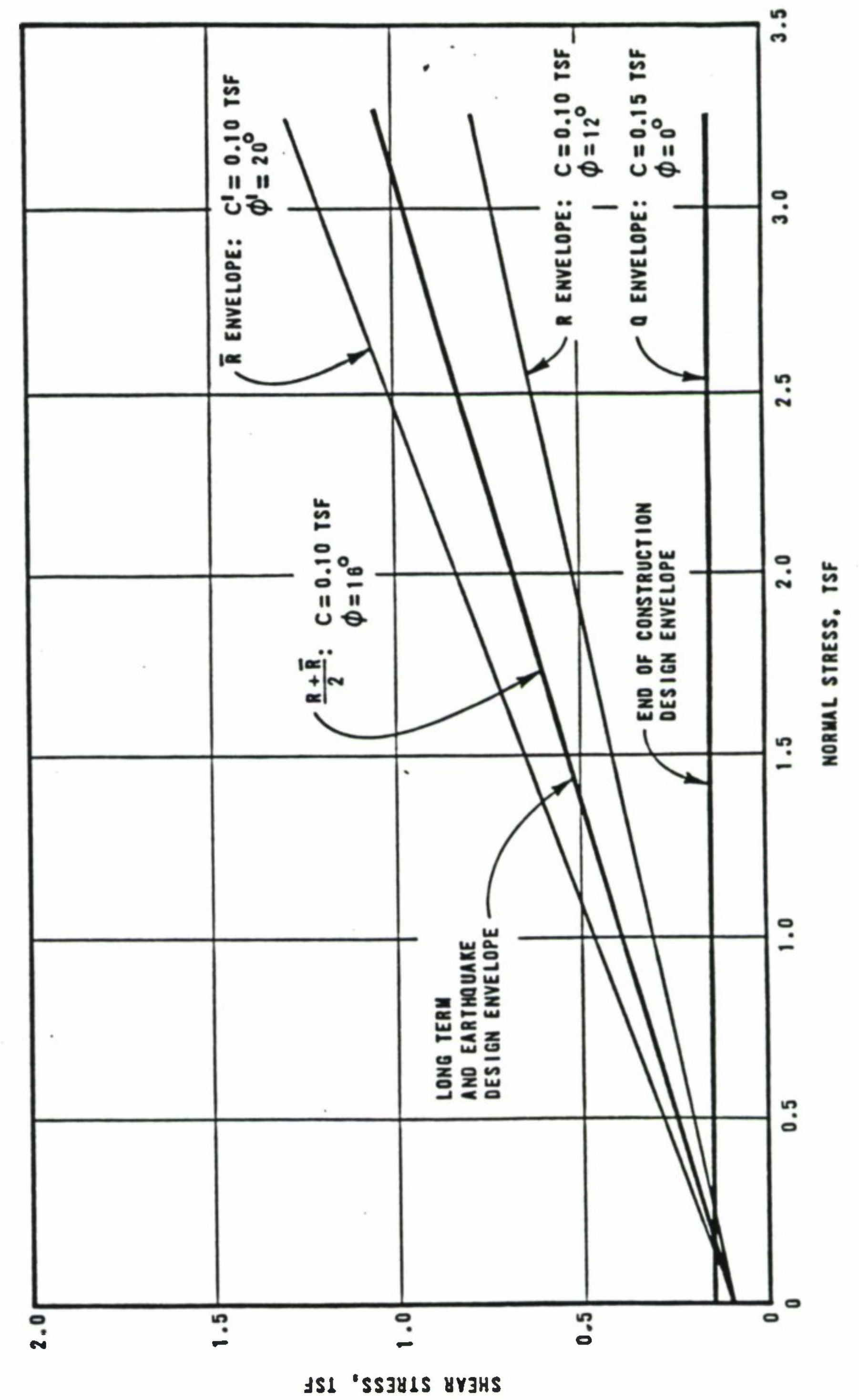


LOADED SOFTER FOUNDATION
STABILITY ANALYSIS SHEAR STRENGTH PARAMETERS

CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
SOLANO COUNTY, CALIFORNIA

FIGURE III-5

154W

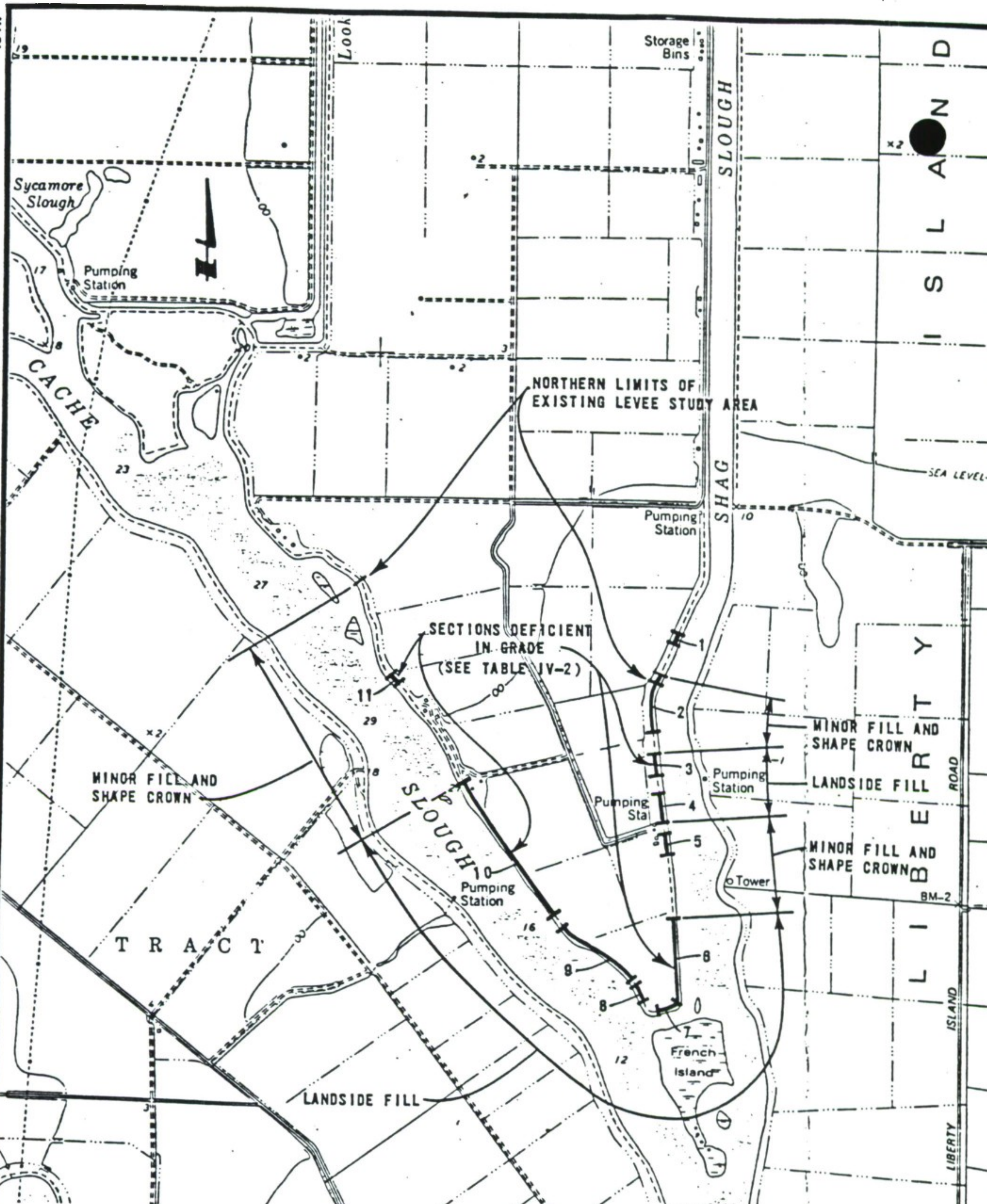


MATERIAL DESIGNATION 2B: SOFTER FOUNDATION - BEYOND TOE OF EXISTING LEVEE

UNLOADED SOFTER FOUNDATION
STABILITY ANALYSIS SHEAR STRENGTH PARAMETERS

CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
SOLANO COUNTY, CALIFORNIA

FIGURE III-6



BASE FROM USGS CALIFORNIA, 7.5 MINUTE SERIES, LIBERTY ISLAND TOPOGRAPHIC QUADRANGLE, 1978.

SECTIONS OF EXISTING LEVEE DEFICIENT IN GRADE AND PROPOSED REPAIR

CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
SOLANO COUNTY, CALIFORNIA

FIGURE III-7

21. Costs. -

a. Basis of costs. - The detailed estimate of first cost given in the following tables is based on 1 October 1986 price levels. The estimated cost of lands was obtained informally from the State of California. The estimated costs of the construction items were determined based on the assumption as described fully in the following paragraphs. The estimates include 15 percent for contingencies, 12 percent for the Engineering and Design (E&D) and 8 percent for Supervision and Administration (S&A), except for selected plan where 19 percent for the E&D and 8 percent for S&A is used.

Construction cost estimates were made for the existing levee repair design and the three cross levee design alternatives described in the previous section in equivalent detail. The cost estimate for the existing levee repair is presented under Plan 1 (Table IV-2), and the cost estimates for the three cross levee alternatives are presented under Plans 2 through 4 (Table IV-1, IV-3, IV-4). Each cost estimate lists the estimated quantity, unit price, and estimated cost for each item associated with the work. All estimated costs are based on 1 October 1986 dollars, and the estimates include all major costs associated with the work. Table IV-5 summarizes the total estimated costs for easier comparison of the alternatives.

The determination of estimated quantities, which provided the basis for the cost estimates, was based on the following assumptions and criteria:

- Clearing and grubbing within limits 5 feet outside areas requiring excavation or fill, including existing levee slopes to receive riprap, measured on horizontal area basis.

- Stripping over all cut and fill areas, including existing levee slopes to receive riprap, to an average depth of 12 inches, and over the northern half of Borrow Area A to an average depth of 6 inches.

- Foundation excavation to form an inspection trench beneath the cross levee with a configration as shown on Plate 20 and other minor excavation, as required, mostly around existing drainage ditches to be covered, to remove particularly wet and soft materials, based on in-place volume prior to excavation.

- Import levee fill volume, based on total required in-place fill volume, accounting for stripping, from average cross section over lengths of required construction, reduced by the available volume of on-site material.

- On-site levee fill volume available from required existing levee degrading to form waterside berm, based on in-place volume for 12-foot wide, 4-inch thick layer along crown of all landside fill and cross levee sections and other areas where minor fill and shaping of the existing levee crown is estimated to be required, and based on 2 tons per in-place cubic yard.

- Riprap slope protection according to the design details on Plates 16 and 20 on the waterside slope of the existing levee along the entire 2.4-mile study area for the existing levee repair design, and on the south slope of the cross levee plus the waterside slope of the existing levee north of the cross levee and within the study area for the cross levee design alternatives, based on 1.75 tons per in-place cubic yard.

- Hydroseeding all remaining slopes not receiving riprap, based on actual slope area measure.

- Areas of real estate for fee title purchase on landward side of existing levee landside toe drainage ditch to be occupied by new fill.

- Twelve-foot wide strip of land on landward side of fee title real estate for easement.

- Areas of real estate for flood easement on landward side of existing levee landside toe drainage ditch and south of cross levee embankment limits.

The estimated earthwork unit prices listed in the cost estimate tables are based primarily on discussions with local contractors with the capability and experience to perform the required work. The development of estimated earthwork unit costs was based on the following assumptions and criteria:

- Required off-site disposal of waste material generated by clearing and grubbing.

- On-site disposal of stripping in a graded stockpile, sloped to drain.

- Reuse of foundation excavation material in required fill or on-site disposal of excessively wet or undesirable material.

- Import levee fill unit price includes borrow excavation, loading, hauling, placement, moisture conditioning, and compaction, based on a maximum haul distance from Borrow Area A of 18 miles.

- On-site levee fill unit price includes existing levee degrading excavation, loading, hauling to required fill, placement, moisture conditioning, and compaction.

- Patrol road crushed aggregate unit price includes material purchase from commercial source, haul to site, and placement.

- Riprap slope protection unit price includes material purchase, transport to site, and placement.

Estimated fee title real estate costs are based on discussions with a representative of the current landowner and State Reclamation Board appraisal department personnel. The landside easement real estate cost is estimated at 50 percent of the fee title value, and the flowage easement real estate cost is estimated at 80 percent of the fee title value. A cost item for haul roads is included in the estimates and includes an approximation for road upgrading, maintenance, and repair for the haul route from Borrow Area, and temporary access across the toe drain to Borrow Area on the west side of the

Sacramento Deep Water Ship Channel. Miscellaneous costs indicated in the estimates are provided to include an estimate for minor cost items such as settlement monument instrumentation and utility relocations. A 15 percent contingency is added to the subtotal estimated cost to account for uncertainties.

b. First Cost. - The total estimated first cost of the project, based on 1 October 1986 price level, is $6,918,000 of which $5,424,000 is a federal cost and $1,494,000 is a non-federal cost. A detailed break down of first cost is described under the Selected Plan (Plan 3-Cross Levee Alternative 2).

c. Annual Costs. - The annual cost for the selected plan, Cross Levee Alternative 2, was calculated based on an interest rate of 8-5/8% and a 50 year amortization period. Annual costs are shown in Table IV-6.

d. Maintenance Cost. - The change in the present maintenance cost due to construction of this will be negligible.

Table IV-1
Cache Slough and Yolo Bypass Levees
SELECTED PLAN - (Cross Levee Alternative 2)
Estimate of First Cost
(1 October 1986 Price level

COST: ACCT: NO:	Description	Unit	Quantity	Unit Cost	Amount $
		FEDERAL			
11	LEVEES				
	Clearing and Grubbing	A.C.	20	1,000.00	20,000
	Stripping	C.Y.	104,000	2.00	208,000
	Foundation Excavation	C.Y.	15,000	3.00	45,000
	LEVEE Fill - Import	C.Y.	365,000	8.50	3,103,000
	LEVEE Fill - on-site	C.Y.	-	-	-
	Crushed Aggregate - Patrol Road	TON	1,200	12.50	15,000
	Riprap	TON	19,000	16.00	304,000
	Slope Protection - Hydroseeding	S.F.	366,700	.03	11,000
	Sub-Total				3,706,000
	Contingencies 15%				536,000
	Total Levees				4,242,000
30	Engineering and Design				800,000
31	Supervision and Administration				382,000
		Total Federal Cost			$5,424,000

Table IV-1
Cache Slough and Yolo Bypass Levees (Continued)
SELECTED PLAN - (Cross Levee Alternative 2)
Estimate of First Cost
(1 October 1986 Price level)

COST: ACCT: NO:	Description	Unit	Quantity	Unit Cost	Amount $
01	LANDS AND DAMAES				
	Real Estate Fee Title	A.C.	14.8	2,500	37,000
	Real Estate Land Easement	A.C.	0.8	1,250	1,000
	Real Estate Flood Easement	A.C.	128	2,000	256,000
	Haul Road & Miscellaneous	L.S.	1	315,000	315,000
	Sub-Total				609,000
	Contingencies 15%				91,000
	Sub-Total				700,000
02	RELOCATION				
	Home & Outbuildings	L.S.	1	40,000	40,000
	Double Wide Mobile Home	L.S.	1	25,000	25,000
	Pumping Plant (includes utility relocation cost)	L.S.	1	400,000	400,000
	Sub-Total				465,000
	Contingencies 15%				70,000
	Sub-Total				535,000
	Non-Federal Sub-Total				1,235,000
30	Engineering and Design				148,000
31	Supervision and Administration				111,000
		Total Non Federal Cost			$1,494,000
		Total First Cost			$6,918,000

Table IV-2
Cache Slough and Yolo Bypass Levees
PLAN 1 - Existing Levee Repair
Estimate of First Cost
(1 October 1986 Price level

COST: ACCT: NO:	Description	Unit	Quantity	Unit Cost	Amount $
		FEDERAL			
11	LEVEES				
	Clearing and Grubbing	A.C.	62	1,000.00	62,000
	Stripping	C.Y.	169,000	2.00	338,000
	Foundation Excavation	C.Y.	30,000	3.00	90,000
	LEVEE Fill - Import	C.Y.	619,060	8.50	5,262,000
	LEVEE Fill - on-site	C.Y.	86,000	2.50	215,000
	Crushed Aggregate - Patrol Road	TON	3,000	12.50	38,000
	Riprap	TON	38,000	16.00	608,000
	Slope Protection - Hydroseeding	S.F.	733,300	.03	22,000
	Sub-Total				6,635,000
	Contingencies 15%				1,006,000
	Total Levees				7,641,000
30	Engineering and Design				917,000
31	Supervision and Administration				685,000
		Total Federal Cost			$9,243,000

Table IV-2
Cache Slough and Yolo Bypass Levees (Continued)
PLAN 1 - Existing Levee Repair
Estimate of First Cost
(1 October 1986 Price level)

COST: ACCT: NO:	Description	Unit	Quantity	Unit Cost	Amount $
01	LANDS AND DAMAES				
	Real Estate Fee Title	A.C.	17.3	2,485.55	43,000
	Real Estate Land Side Easement	A.C.	2.0	1,500.00	3,000
	Real Estate Flood Easement	-	-	-	-
	Haul Road & Miscellaneous Easement	L.S.	-	330,000	330,000
	Sub-Total				376,000
	Contingencies 15%				57,000
	Total Lands				433,000
30	Engineering and Design				51,000
31	Supervision and Administration				38,000
		Total Non Federal Cost			$522,000
		Total First Cost			$9,765,000

Table IV-3
Cache Slough and Yolo Bypass Levees
PLAN 2 - Cross Levee Alternative [1]
Estimate of First Cost
(1 October 1986 Price level

COST: ACCT: NO:	Description	Unit	Quantity	Unit Cost	Amount $
		FEDERAL			
11	LEVEES				
	Clearing and Grubbing	A.C.	43.00	1,000.00	43,000
	Stripping	C.Y.	140,000	2.00	280,000
	Foundation Excavation	C.Y.	25,000	3.00	75,000
	LEVEE Fill - Import	C.Y.	570,000	8.50	4,845,000
	LEVEE Fill - on-site	C.Y.	41,200	2.50	103,000
	Crushed Aggregate - Patrol Road	TON	2,240	12.50	28,000
	Riprap	TON	29,000	16.00	464,000
	Slope Protection - Hydroseeding	S.F.	733,300	.03	22,000
	Sub-Total				5,860,000
	Contingencies 15%				880,000
	Total Levees				6,740,000
30	Engineering and Design				810,000
31	Supervision and Administration				600,000
	Total Federal Cost				$8,150,000

Table IV-3
Cache Slough and Yolo Bypass Levees (Continued)
PLAN 2 - Cross Levee Alternative [1]
Estimate of First Cost
(1 October 1986 Price level

COST: ACCT: NO:	Description	Unit	Quantity	Unit Cost	Amount $
01	LANDS AND DAMAGES				
	Real Estate Fee Title	A.C.	18.8	2,500	47,000
	Real Estate Land Side Easement	A.C.	1.6	1,250	2,000
	Real Estate Flood Easement	A.C.	31.0	2,000	62,000
	Haul Road & Miscellaneous Easement	L.S.	1	335,000	335,000
	Sub-Total				446,000
	Contingencies 15%				66,000
	Total Levees				512,000
30	Engineering and Design				60,000
31	Supervision and Administration				50,000
		Total Non Federal Cost			$ 622,000
		Total First Cost			$8,772,000

Table IV-4
Cache Slough and Yolo Bypass Levees
PLAN 4 - Cross Levee Alternative 3
Estimate of First Cost
(1 October 1986 Price level

COST: ACCT: NO:	Description	Unit	Quantity	Unit Cost	Amount $
	FEDERAL				
11	LEVEES				
	Clearing and Grubbing	A.C.	36	1,000.00	36,000
	Stripping	C.Y.	130,000	2.00	260,000
	Foundation Excavation	C.Y.	30,000	3.00	90,000
	LEVEE Fill - Import	C.Y.	761,060	8.50	6,469,000
	LEVEE Fill - on-site	C.Y.	-	-	-
	Crushed Aggregate - Patrol Road	TON	2,000	12.50	25,000
	Riprap	TON	17,000	16.00	272,000
	Slope Protection - Hydroseeding	S.F.	866,700	.03	26,000
	Sub-Total				7,178,000
	Contingencies 15%				1,077,000
	Total Levees				8,255,000
30	Engineering and Design				991,000
31	Supervision and Administration				740,000
	Total Federal Cost				$9,986,000

Table IV-4
Cache Slough and Yolo Bypass Levees (Continued)
PLAN 4 - Cross Levee Alternative 3
Estimate of First Cost
(1 October 1986 Price level

COST: ACCT: NO:	Description	Unit	Quantity	Unit Cost	Amount
$					
01	LANDS AND DAMAES				
	Real Estate Fee Title	A.C.	34.4	2,500	86,000
	Real Estate Land Side Easement	A.C.	1.6	12,500	2,000
	Real Estate Flood Easement	A.C.	458	2,000	916,000
	Haul Road & Miscellaneous Easement	L.S.	1	310,000	310,000
	Sub-Total				1,314,000
	Contingencies 15%				197,000
	Total Levees				1,511,000
30	Engineering and Design				181,000
31	Supervision and Administration				135,000
		Total Non Federal Cost			$1,827,000
		Total First Cost			$11,813,000

TABLE IV-5

SUMMARY OF SELECTED PLAN AND ALTERNATIVE COST ESTIMATES

Alternative	Total Estimated First Cost No Levee Degrading
Selected Plan (Cross Levee Alternative 2)	6,629,000
Existing Levee Repair	9,765,000
Cross Levee Alternative 1	8,772,000
Cross Levee Alternative 3	11,813,000

TABLE IV-6

SUMMARY OF AVERAGE ANNUAL COSTS

Alternative	Total Annual Cost No Levee Degrading
Selected Plan (Cross Levee Alternative 2)	$581,000
Existing Levee Repair	856,000
Cross Levee Alternative 1	769,000
Cross Levee Alternative 3	1,036,000

22. Benefits and Project Justification. - This work will complete the project work on the Sacramento River Flood Control Project. Its economics cannot be analyzed independently. Overall project justification has been given in various project documents.

It should be noted the cross levee alignment selected plan removes from project levee protection 128 acres of land. Cross levee alternatives 1 and 3 remove 31 to 468 acres of land from project levee protection respectively. The real estate costs for each of these alternatives are very minor compared to the differences in first costs. The selected plan (cross levee alternative 2) was clearly the most economical and least costly levee plan.

23. Construction Considerations. -

a. General. - This chapter discusses aspects of normal earthwork common to embankment fill construction and applicable to this project. Techniques required for foundation preparation and embankment construction of the existing levee repair and the cross levee designs are presented. In addition, special construction considerations and constraints required by the design are discussed.

b. Foundation Preparation. - Prior to levee embankment construction, areas to be occupied by new fill or requiring excavation will require clearing, grubbing, and stripping. Clearing consists of the removal and disposal of all trees, fallen timber, brush, vegetation, man-made structures, and other buried or objectionable matter above the ground surface. Grubbing consists of the removal of all stumps, roots, buried logs, old drains, old structure foundations, and other buried objectionable matter. After foundation clearing and grubbing, stripping will be required to remove low growing vegetation and organic topsoil.

Foundation excavation of an inspection trench beneath the cross levee is required prior to embankment construction, according to the configuration and limitations indicated on Plate 20. Other excavation may be required for foundation preparation for the existing levee landside fill and/or cross levee to remove particularly wet and soft materials, particularly around existing drainage ditches to be covered, and other additional objectionable material, as necessary. It is recommended that these ditches be constructed a minimum of 50 feet from the toe of the landside or cross levee berms.

Just prior to fill placement, the foundation surface should be scarified to obtain a good bond between fill and foundation. Major construction difficulties from potential foundation instability, caused by equipment loading on the foundation surface during final preparation and during initial fill placement, are not expected. Some localized soft areas could require stabilization with, for instance, a ground-stabilizing fabric material.

c. Embankment Construction. - Levee embankment construction for the cross levee will require placement, moisture conditioning, and compaction of thin lifts of designated borrow materials. Each lift will require compaction to not less than 95 percent of the laboratory maximum dry density of the material according to the currently accepted testing procedures of the American Society for Testing and Materials (ASTM Designation D 698-78), which is equivalent to the Engineering Manual 1110-2-1906 standard compaction test. The in-place compacted embankment materials will require control to meet specified conditions. Density and moisture content tests of compacted embankment materials should be taken at specified intervals to check that the requried degree of compaction is being attained. Material control tests, such as gradation and compaction tests, will be performed to check the acceptability and establish the properties of borrow material.

d. Special Considerations. - Certain special considerations and constraints on construction are required by the design and are listed below:

- o It is extremely important that construction of the existing levee landside fill and/or cross levee is performed by placement and compaction of the embankment material in continuous and approximately horizontal layers to the full width of the design section. For example, berm construction cannot follow construction of a major portion of the main embankment section without jeopardizing foundation and embankment stability.

- o Certain reaches of levee embankment construction should not be allowed to advance ahead of adjacent reaches by a height of more than 5 feet, also for foundation and embankment stability related reasons. Transverse bonding slopes between adjacent reaches of levee embankment construction should not be steeper than 4 horizontal to 1 vertical.

- o If feasible, an effort will be made to selectively borrow and route embankment materials obtained from Borrow Area A such that the sandier, less plastic materials are placed near the surface of the main embankment section in order to reduce the potential for cracking caused by desiccation.

- o Although no particular requirements or constraints are put on size and type of construction equipment at this time since the designs are based on end of construction, undrained conditions, equipment operation and embankment performance will be monitored during construction, and adjustments made to equipment size and speed, as necessary.

24. Construction Schedule. - It is estimated that 200 calendar days will be required to complete the project work unit. The time is predicted on the construction quantities, locality, construction season, and type of construction. Since the work is scheduled to commence on as early in the season as possible, only one construction season will be needed to complete the construction of this unit.

25. Funding. - Based on 1 October 1986 price levels, the total construction cost is $4.3 million. Total Federal Cost is estimated at about $5.4 million. Funding of $250,000 was provided in FY 85 and 86 and additional funding of $300,000 in FY 87 and remaining $4.4 million in FY 88 to complete the project work. The amounts for FY 87 and FY 88 do not include any inflation allowances.

CHAPTER VI - ENVIRONMENTAL COORDINATION

26. Environmental Coordination. - An Environmental Assessment (EA) has been prepared for this project. The EA, along with the draft finding of no significant impact, is included in Appendix A. Field visits and staff discussions have been carried out with the U.S. Fish and Wildlife Service (Ecological Services) to provide input to the EA. The results of the coordination are shown in FWS Planning Aid Letter dated 19 December 1985. The endangered species office of the U.S. Fish and Wildlife Service in their letter of 22 January 1986 identified five candidate species that may occur in the area of the project. These are California tiger salamander, Giant garter snake, California hibiscus, Delta-tule pea, and Mason's lilaeopsis. Further coordination with FWS will determine whether any habitat for these species will be affected by the project. Consultation with the California State Historic Preservation Officer (SHPO) is currently in progress. A report documenting the intensive cultural resources survey has been submitted to both the California State Historic Preservation Officer and Interagency Archeological Services of the National Park Service review. Additionally, a copy of has been supplied to the Northwest Information Center of the California Archeological Inventory for inclusion in the state archeolgical data files. The results of this coordination has been incorporated into the EA.

A draft of the EA was sent for review to the Environmental Protection Agency, U.S. Fish and Wildlife Service, National Park Service, National Marine Fisheries Service, Solano County, and the following State agencies: Resources Agency, Department of Water Resources, Reclamation Board, Department of Fish and Game, and State Historic Preservation Officer. A Notice of Availability for the EA was circulated for information to other concerned agencies and interested individuals. Comments received were incorporated into the body of the final EA as appropriate.

CHAPTER VII - LOCAL COOPERATION AND VIEWS OF LOCAL INTERESTS

27. Local Cooperation. - The requirements of local cooperation as contained in the Memorandum of Understanding dated 30 November 1953 for the Sacramento River Flood Control Project are briefly restated in here for reference.

Local interests will:

a. Furnishing lands, easements and rights of way; bear the expense of necessary highway, utility and bridge alterations.

b. Hold and save the United States free from claims for damages due to construction of the works.

c. Operate and maintain of all the works, after completion, in accordance with regulations prescribed by the Secretary of the Army.

28. Views of Local Interests. - Reclamation District 2098 representatives support the Cross levee alternative 2 as the selected plan, provided the State Reclamation Board assures that the existing irrigation and drain ditch and drain pump structure are relocated/replaced under this construction.

Chapter VIII - CONCLUSION AND RECOMMENDATION

29. General. - The plan described in this supplement is considered to be consistent with the project authorization. Functionally and structurally, it is considered adequate to provide the authorized degree of protection. Accordingly, it is recommended that the Supplement No. 1 to DM No. 13 for this project unit be approved and the Sacramento District be authorized to proceed with preparation of plans and specifications.

SUPPLEMENT NO. 1 TO DESIGN MEMORANDUM NO. 13

SACRAMENTO RIVER FLOOD CONTROL PROJECT

RIGHT BANK YOLO BYPASS AND LEFT BANK
CACHE SLOUGH NEAR JUNCTION YOLO BYPASS
AND CACHE SLOUGH.

APPENDIX A

U.S. ARMY CORPS OF ENGINEERS-SACRAMENTO DISTRICT

APPENDIX A

TABLE OF CONTENTS

November 5, 1985

SPKED-D

Mr. Raymond E. Barsch, General Manager
The Reclamation Board
1416 Ninth Street, Room 455-6
Sacramento, California 95814

Dear Mr. Barsch:

As we have informed you earlier by letters dated July 13, 1983 and February 28, 1985, the Sacramento District has received approval from the Chief of Engineers to investigate remedial measures for the subsidence and slip areas in the levee near the junction of Cache Slough and Yolo Bypass, Sacramento River Flood Control Project (SRFCP).

The Sacramento District has completed the three phase geotechnical investigation of the site, the borrow area and the design analysis for four alternatives. The four alternatives are described here for your information. Alternative 1 consists of repairing the existing levee with a redesigned cross-section and a minor change in the existing alignment. The other three alternatives are cross levee design alternatives. Each of the three alternatives would involve construction of a cross levee at a different specified location and repairing the existing levees within the study area north of the cross levee. Our preliminary cost estimates favor Cross Levee Alternative 2 which will require further acquisition of about 145 acres of farmland in fee title and easements. We are also calculating average annual damages and benefits to develop benefit cost (B/C) ratio for each alternative. Once we have finalized B/C ratio for each alternative, we need to coordinate with you in selecting a viable solution to prepare final plans. We are forwarding a copy of the final report on Cache Slough and right bank of Yolo-Bypass for your review and comments.

The State of California through the State Reclamation Board is local sponsor for the Cache Slough-Yolo Bypass levees (SRFCP). To proceed with the final design and to obtain approval for this project, we will require a letter of consent, and reassurance indicating a willingness to provide the necessary local cooperation requirements listed in our 1953 Memo

of Understanding. To accomplish the above tasks and to seek concurrence to the formulated design plan to repair this portion of the project levees, we suggest that we all meet together with the local Reclamation District (RD 2098) at the earliest possible date to resolve outstanding issues, if any.

If you need additional information or to arrange for a meeting with the local sponsor, please do not hesitate to call our contact person, Mr. Ram Kalia, telephone 551-2046.

Sincerely,

Enclosure

Albert E. McCollam, Jr.
Lieutenant Colonel, Corps of Engineers
Acting District Engineer

STATE OF CALIFORNIA—RESOURCES AGENCY GEORGE DEUKMEJIAN, *Governor*

DEPARTMENT OF WATER RESOURCES
THE RECLAMATION BOARD
1416 – 9th Street, Room 455-6
Sacramento, CA 95814
(916) 445-9454

JAN 2 2 1986

Colonel Wayne J. Scholl
District Engineer
Sacramento District
U. S. Army Corps of Engineers
650 Capitol Mall
Sacramento, CA 95814

Dear Colonel Scholl:

This is in response to your letter of November 5, 1985 concerning your request for comments on the Geotechnical Report on the levees in Reclamation District 2098 along Shag and Cache Sloughs.

As a result of your request, two meetings were held and a field inspection was made. From these meetings, the following agreement was reached. Alternative No. 2 shown in the report with its cross levee at an estimated cost of over $5,000,000 is supported by Reclamation District 2098 and the staff for The Reclamation Board. The Reclamation Board, under its existing agreement for the Reclamation District 2098 levees under the Sacramento River Flood Control Project, will continue to provide the necessary assurances. This consists of acquiring lands, easements, rights of way, and relocation of the drainage pump and appurtenances, maintaining the cross levee, and holding the U. S. Government harmless from lawsuit. Funding for lands, easements, rights of way, and relocations will be budgeted for 1987-88.

To brief The Reclamation Board on your proposal and our agreement, I request that members of your staff present the alternatives to the Board at its regular meeting on February 21 starting at 10 a.m. in the Resources Building Auditorium.

If you have further questions on this project, please contact Robert L. Manning at 445-9457.

Sincerely,

RAYMOND E. BARSCH
General Manager

cc: (See attached list.)

cc: Mr. John Wright
Murray, Burns and Kienlen
2012 H Street, Suite 201
Sacramento, CA 95814

Mr. V. B. Brownell, Secretary
Reclamation District No. 2098
5399 Malcolm Lane
Liberty Farms, CA 95620

Mr. George Basye, Attorney
Reclamation District 2098
555 Capitol Mall, Suite 1050
Sacramento, CA 95814

February 14, 1986

Environmental Resources Branch

Mr. James J. McKevitt
Field Supervisor
Ecological Services
Fish and Wildlife Service
2800 Cottage Way, Room E-1803
Sacramento, California 95828

Dear Mr. McKevitt:

This responds to the recommendations contained in your December 19, 1985 planning aid letter (PAL) for the Sacramento River Flood Control project (Cache Slough-Yolo Bypass) in Solano County, California. We concur with your recommendation to reseed disturbed areas with native grasses.

Since receiving your PAL, design has been proceeding. Please note the following changes to the data furnished your previously. The project alternatives covered in your PAL have been reduced to a single recommended plan which is the cross-levee plan described as Alternative No. 3. The existing levees which will remain north of the cross-levee will not be widened as described in your PAL. Localized areas of the levee will be filled, and the entire crown of the levee will be reshaped. This means that there will not be a waterside berm on these levees and that only vegetation on the crown of the levee, which is not occupied by a road, and in the areas where fill is needed to repair subsidence will be disturbed. It does not appear that these changes require a change in your PAL.

We are unable to concur with recommendation No. 1, that conservation and development of fish and wildlife resources be included among the purposes for which the project is to be authorized. The work planned is to complete the construction of the Cache Slough-Yolo Bypass levee under the Sacramento River Flood Control project. No new authorization is being sought.

If you have any questions concerning the above, please contact Mr. Ram Kalia at (916) 551-2046.

Sincerely,

Albert E. McCollam, Jr.
Lieutenant Colonel, Corps of Engineers
Acting District Engineer

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814 4794

REPLY TO
ATTENTION OF

May 1986

Final Environmental Assessment

for

CACHE SLOUGH-YOLO BYPASS LEVEES,

SACRAMENTO RIVER FLOOD CONTROL PROJECT

1. Purpose of this Environmental Assessment (EA). This EA describes alternatives to solve the subsidence problems of the levees at the junction of Cache Slough and Shag Slough at the lower end of the Yolo Bypass. It is intended to provide sufficient information on the potential environmental effects to determine whether an environmental impact statement (EIS) is necessary. An EIS was not prepared for the Sacramento River Flood Control Project of which these levees are a part.

2. Authorization.- The Sacramento River Flood Control Project was authorized by the Flood Control Act approved 1 March 1917, (Public Law 367, 64th Congress, first session) as modified by the Flood Control Act approved 15 May 1928, the River and Harbor Act approved 26 August 1937 and the Flood Control Act approved 18 August 1941.

3. Status of the Project. - Completed work of the Sacramento River Flood Control Project was turned over to The Reclamation Board of the State of California for operation and maintenance. The section between Cache Slough and Shag Slough, was not accepted by The Reclamation Board for maintenance due to recurring problems with stability and subsidence.

4. Need for the Proposed Action. - Persistant subsidence problems in the subject levees have resulted in a need for repeated levee repairs and presents a continuing flood hazard to the area between Shag and Cache Sloughs. Stabilization of the existing levees, or bypassing them with one of the cross levee alternatives would relieve this flood hazard and allow this portion of the project to be turned over to The Reclamation Board for operation and maintenance.

5. Alternatives to the Proposed Action. - The existing levees can continue to be repaired on an emergency basis. In the event of such a no action alternative, eventual levee failure could occur

due to continued subsidence and/or overtopping. Work to date has not resulted in keeping the levees at design elevation. Failure would lead to the inundation of 13,000 acres of farmlands together with related houses, buildings, and roads. In addition to the no action plan and the recommended plan (paragraph 6), three alternative plans were considered. One alternative consists of rebuilding 12,700 linear feet of the existing levee to widen the cross section by extending it inland. Each of the other two alternatives involve construction of a cross levee at a different location than the one selected for the recommended plan and repairing any of the existing levee that would remain north of the cross levee.

6. Description of the Recommended Plan. – The plan now recommended consists of the construction of a cross levee from Cache Slough to Shag Slough, and the repair of the existing levees north of the cross levee. This will leave 128 acres of farmland south of the cross levee unprotected by project levees. The existing levees south of the cross levee will remain but to maintain or not to maintain them will become the responsibility of the landowners. The cross section for the cross levee will include a berm on both sides . The existing levees to be repaired north of the cross levee will have a reshaped crown and be brought up to design elevation. The repaired and new levees will be riprapped on the waterside. Two 50 HP pumps will be installed north of the cutoff levee to pump water from the existing drainage channel to Shag Slough.

7. Changes in Project Purpose. – None.

8. Current Local Cooperation Requirements. – Local interests are required to provide without cost to the United States all lands, easements and rights-of-way necessary for the construction of the project; to hold and save the United States free from damages due to the construction work; to maintain and operate all works after completion in accordance with regulations prescribed by the Secretary of the Army; and to bear the cost of all utility relocations and modifications. The State of California, by legislation passed in 1939 (Senate Bill No. 950), provided the necessary assurances of local cooperation. No cash contribution is required. The agency of the State authorized to handle all matters pertaining to local interest cooperation is The Reclamation Board.

9. Environmental Assessment. – The environmental impacts associated with the construction of the recommended plan or its alternatives are discussed in this section.

(a) Impacts to Vegetation. – Construction of the selected cross levee plan will result in the conversion of 18 acres of agricultural land to levees. There would be a temporary minor habitat loss due to construction activities. However, it is expected that revegetation of the levee slopes will prevent any permanent loss of habitat. There would also be a conversion from

cropland to grassland vegetation on the new levee. In order to mitigate for temporary habitat loss, disturbed areas would be reseeded with native grasses. In the event that the land south of the cutoff levee is innundated at a future date, then the vegetation on the water side of the cutoff levee would convert to a combination of open waters, riparian and wetland vegetation, and the existing levees south of the cutoff levees would form islands of riparian vegetation in a wetland habitat as has already occured to abandoned levees in Cache Slough.

(b) Impacts to Fisheries. - Construction of the cross levee alternative will have no effect on fish as long as the existing levees south of the cutoff levee remain intact. In the event of their failure, the 128 acres of existing farmland will be converted to an equal amount of aquatic habitat for freshwater or anadromous fish. Since most of the lands south of the cutoff levee are below sea level this area would become a shallow freshwater tidal basin.

(c) Impacts to Wildlife. - Construction of the cross levee and repair of the existing levees north of the new levee would convert 18 acres of existing farmland to levees. Although there will be some natural revegetation, it probably will take about 10 years before wildlife habitat values on the repaired levees return to existing levels. Grassland values for wildlife should return in one or two years following project completion. Should the existing levees south of the recommended cutoff levee fail at a future date, this would result in a loss of agriculture and grassland wildlife values and an increase in wetland associated wildlife values for the affected 128 acres..

(d) Impacts to Endangered Species. - No listed or proposed threatened or endangered species are found in the project area. However the endangered species office of the U.S. Fish and Wildlife Service in their letter of 22 January 1986 identified five candidate species that may occur in the area of the project. These are California tiger salamander, giant garter snake, California hibiscus, Delta-tule pea, and Mason's lilaeopsis. An inspection of the project area on 20 April 1986 did not locate specimens of any of the candidate species. FWS has provided comments on the draft EA which are shown in attachment # 3. Accordingly, no impact is anticipated to any threatened or endangered species.

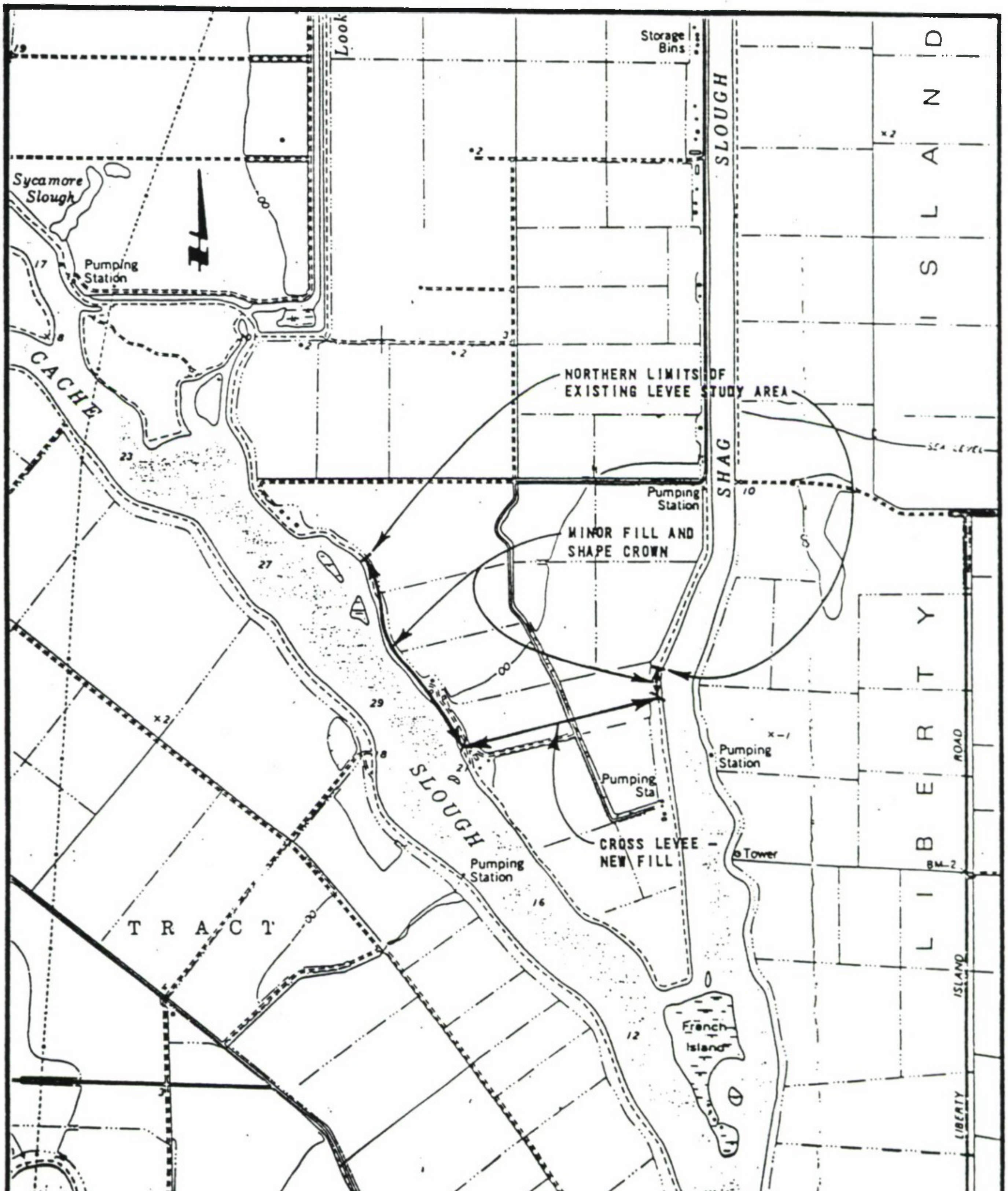
(e) Impacts to Land Use. - Eighteen acres would be converted from agricultural use to levees. South of the cutoff levee, 128 acres of agricultural land would have less flood protection than that afforded by Federal project levees. Maintenance would be the decision of Reclamation District # 2098. In the event that it becomes economically or structurally infeasible to maintain these levees, their failure would cause this land to revert to aquatic habitat with the existing levees forming islands of riparian habitat, like those that exist presently on former levees in Cache Slough.

(f) Impacts to Cultural Resources. - Consultation with the State Historic Preservation Officer (SHPO) is currently in progress. In response to circulation of the draft EA, comments were received from the Native American Heritage Commission and are included here as attachment # 5. An intensive cultural resources survey indicates that there are no prehistoric or historic period cultural values in the project area. No such values were indicated by a pre-field review of existing site location and survey data on file at the Office of Historic Preservation, California Department of Parks and Recreation. A report documenting this investigation has been submitted to both the State Historic Preservation Officer and Interagency Archeological Services of the National Park Service for review. Additionally, a copy of has been supplied to the Northwest Information Center of the California Archeological Inventory for inclusion in the state archeological data files. Based on the results of this effort, it is not anticipated that the project will have any effect on cultural properties. However, should any previously unknown values be discovered in the course of project implementation, construction whould be halted in that area until the Federal requirements (36 CFR 800.7) have been fully met.

10. Coordination of the EA.- Field visits and staff discussions have been carried out with the U.S. Fish and Wildlife Service (Ecological Services) to provide input to the EA. The results of the coordination are shown in FWS Planning Aid Letter dated 19 December 1985 (Attachment # 1), and have been incorporated into this EA. The draft of this EA was sent for review to the Environmental Protection Agency, U.S. Fish and Wildlife Service, National Park Service, National Marine Fisheries Service, Solano County, and the following State agencies: Resources Agency, Department of Water Resources, Reclamation Board, Department of Fish and Game, and State Historic Preservation Officer. A Notice of Availability for this EA was circulated for information to other concerned agencies and interested individuals. Comments were received from U.S. Fish and Wildlife Service, Resources Agency of California, Native American Heritage Commission, and the Sierra Club. Their comments were incorporated into the body of this final EA as appropriate. The completed EA and the executed finding of no significant impact will be provided to the Regional Administrator of EPA for a 15-day period prior to taking any action. Copies will be made available to those interested agencies noted above. A notice of availability of the final EA and finding of no significant impact will be sent to all interested parties.

11. Mitigation. - The mitigation recommended by the Fish and Wildlife Service on 19 December 1985 for alternative 1 (repair of the existing levees) i.e., willow and grass plantings, are concurred with. However, should one of the cross levee plans be adopted, disturbed areas would only be reseeded with native grasses in order to mitigate for temporary habitat loss. This is because the cross levees would not be adjacent to water. Appropriate mitigation will thus be implemented with the project.

Sacramento District
Corps of Engineers



BASE FROM USGS CALIFORNIA, 7.5 MINUTE SERIES,
LIBERTY ISLAND TOPOGRAPHIC QUADRANGLE, 1978.

SCALE

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CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES SOLANO COUNTY, CALIFORNIA	RECOMMENDED PLAN		
	PROJECT NO.	DATE	FIGURE NO.
			APPENDIX A

OZALID

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Division of Ecological Services
2800 Cottage Way, Room E-1803
Sacramento, California 95825

December 19, 1985

District Engineer
Sacramento District, Corps of Engineers
650 Capitol Mall
Sacramento, California 95814

Subject: CE - Sacramento River Bank Protection Project (Cache Slough - Yolo Bypass), Solano County, California

Dear Sir:

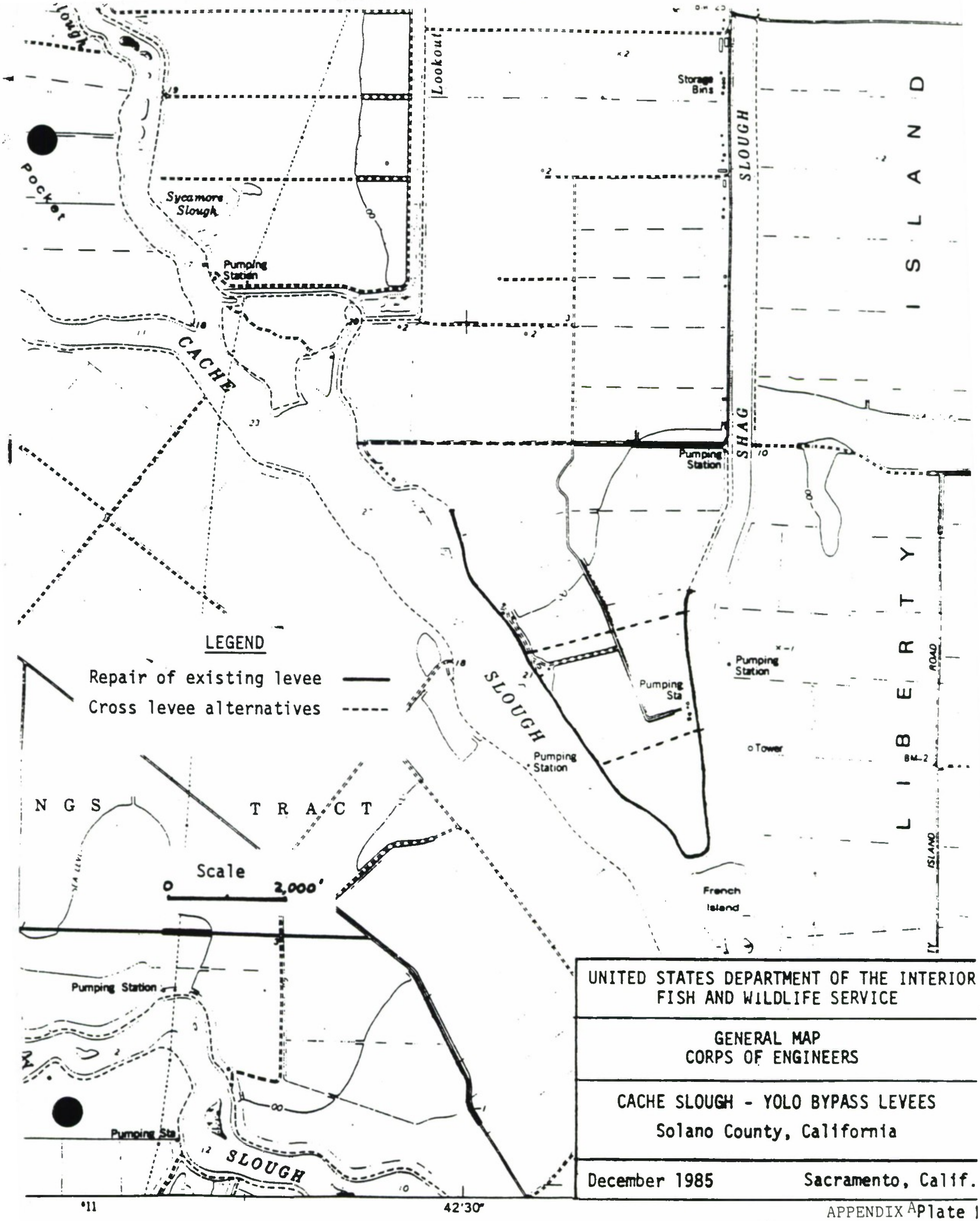
This is our planning aid letter on the effects improvement of the existing levee system will have on fish and wildlife resources. It is for your use in preparing your environmental assessment for the project. This information is provided as technical assistance; it does not constitute our report as called for in Section 2 of the Fish and Wildlife Coordination Act. Our analysis is based on engineering data provided by the Corps prior to December 1985.

Our recommendations are based on the U.S. Fish and Wildlife Service's Mitigation Policy (Federal Register, Volume 46:15, January 23, 1981) which provides internal guidance for establishing appropriate compensation for projects under our purview. Under this policy, resources are divided into four categories to assure that recommended compensation is consistent with the fish and wildlife resources involved. These resources categories cover a range of habitat values from those considered to be unique and irreplaceable to those believed to be of relatively low value to fish and wildlife. In accordance with the policy, we have designated the wetland and riparian habitats in the project area as Resource Category 2. Riparian and wetland habitats are relatively scarce in California and provide essential nesting cover and feeding areas for a variety of wildlife. The mitigation policy is no net loss of "in-kind" habitat value. Grassland and agriculture lands in the ecoregion are abundant and of medium value for evaluation species. As such, these habitats are considered as being in Resource Category 4. The mitigation goal is to minimize loss of habitat value.

DESCRIPTION OF THE AREA

The project is located in the Delta-Central Sierra hydrologic region. Within this area, Cache Slough is the principal tributary to the Sacramento River. Project lands are surrounded by a levee system at the confluence of Cache and Shag Sloughs at the southern end of the Yolo Bypass (Plate I).

Attch 1.



UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

GENERAL MAP
CORPS OF ENGINEERS

CACHE SLOUGH - YOLO BYPASS LEVEES
Solano County, California

December 1985 Sacramento, Calif.

Land use in the project area consists of agricultural crops. Population in the area is rural. Climate consists of hot, dry summers and mild winters with moderate rainfall from November through April.

DESCRIPTION OF THE PROJECT

Completed work of the Sacramento River Flood Control Project was turned over to the California State Reclamation Board for operation and maintenance. The one remaining section between Cache Slough and Yolo Bypass, however, has not been accepted by the Reclamation Board for maintenance due to recurring problems with stability and subsidence.

The Corps is presently evaluating four alternative plans. Alternative 1 consists of repairing 12,700 linear feet of the existing levee with a redesigned cross-section. Each of the other three alternatives will involve construction of a cross levee at one of the three sites being evaluated and repairing the existing levee north of the cross levee. The redesigned cross-sections for all alternatives will include a berm on both the waterside and landside. The elevation of the waterside berm will be above the maximum tide. The existing levee is riprapped on the waterside.

EXISTING CONDITIONS

Aquatic Resources

Aquatic habitat in the project area consists of tidal freshwater sloughs adjacent to the levee. Fish species are typical of those in freshwater tidal sloughs. Anadromous fishes include striped bass, American shad, and green and white sturgeons. The sloughs are used as a nursery area by the young of anadromous fishes and feeding areas for adult fish. Resident warmwater species include white and channel catfish, brown bulhead, and various species of sunfishes. The sport fishery, although unknown, consists mainly of boat fishing.

Wildlife Resources

Wildlife habitat in the project area includes emergent wetland, scrub riparian, upland and agriculture. Within the tidal zone, a relatively narrow and sparse band of bulrush exists adjacent to the toe of the levee. Relatively sparse stands of riparian vegetation occur along the levee toe. Typical plant species include willows, blackberry, grasses and forbs. Of an estimated 5 acres of riparian vegetation, about 2 acres are woody riparian (willow trees). About 20 acres of upland vegetation, mainly annual grasses and forbs, grow on the levee embankments and interior side of the levee. Plant species include common foxtail, wild oat, mustard, thistle and smartweed. There is an estimated 450 acres of croplands in the area. There are a few scattered stands of cattails along the interior canals and drainage ditches.

Wildlife surveys of the project area have not been conducted. However, we expect various species of songbirds, water-associated birds, small mammals, upland game species, amphibians and reptiles to frequent the project area. The emergent wetland vegetation is sparse, but provides some cover and feed

for waterfowl, shorebirds and marsh birds. Woody riparian vegetation is also sparse; however, it provides some nesting cover for songbirds, roost sites for raptors, and foraging areas for small mammals such as raccoon and striped skunk. The grassland provides nesting and feeding cover for meadowlark, ring-necked pheasant, and foraging habitat for the American kestrel and black-shouldered kite. The agricultural land contains little interspersion but probably provides some nesting cover for pheasant and California quail along the canal and drainage ditches. The land is privately-owned and hunting is probably limited to the landowner.

WITHOUT THE PROJECT

Fish and Wildlife

We have no information regarding whether all or part of the levee system will be maintained without federal assistance. However, we have assumed that some repair of the existing levee and/or cross levee will be constructed in order to preserve agricultural croplands in this area.

WITH THE PROJECT

Fish

Rehabilitation of the existing levee system (Alternative 1) will have little adverse impact on aquatic resources in Cache and Shag Sloughs. Placement of rock along the waterside will temporarily impact fish spawning and feeding. However, selection of one of the cross-levee alternatives will result in a major change in the amount of aquatic habitat. The levee south of the cross levee will eventually erode due to land subsidence and wave action. Since most lands within the interior are below sea level, this area will become a shallow freshwater tidal basin. This will increase the amount of aquatic habitat for freshwater fish.

Wildlife

Construction of a berm along 12,700 linear feet of existing levee (Alternative 1) will result in the loss of an estimated two acres of woody riparian habitat. This will reduce nesting cover for songbirds, cover for small mammals, and roosting areas for raptors. Although there will be some natural revegetation, it probably will take about 10 years before wildlife habitat values return to existing levels. Grasslands values for wildlife should return in one or two years following project completion. However, a major change in habitat type will occur if one of the cross levee alternatives is selected. Due to a combination of land subsidence and wave action, breaks will begin to occur in the existing levee south of the cross levee. The interior lands, which are below sea level, will become a shallow freshwater tidal basin. This will result in a loss of agriculture and grassland wildlife values and an increase in wetland associated wildlife values.

DISCUSSION

Construction of Alternative 1 will adversely impact fish and wildlife resources. Fish spawning and feeding will be temporarily disrupted. Construction of the waterside berm will result in the loss of woody riparian vegetation. Grasslands and agricultural lands will not be impacted significantly.

In order to offset the loss of woody riparian vegetation under Alternative 1, we recommend that sandbar willow, Salix hindsianna and Gooding willow, Salix goodingii be planted from the waterside of the berm in a 10-foot wide section along the entire levee system. Planting will assure that wildlife values return to existing conditions. Riparian wildlife values can be significantly enhanced by additional plantings along the berm with willows and other riparian type trees. Loss of grassland wildlife values will be offset by the Corps' program of reseeding disturbed areas with native grasses.

Construction of one of the cross-levee alternatives will result in major change in habitat types as discussed earlier. There would be an increase in the amount of freshwater tidal habitat for fish and wetland-associated wildlife species.

RECOMMENDATIONS

We recommend:

1. That the report of the District Engineer, Corps of Engineers, include the conservation and development of fish and wildlife resources among the purposes for which the project is to be authorized.

2. That a planting program as described in the Discussion Section be implemented. Costs should be a project cost.

We appreciate the opportunity to provide input to the planning process.

Sincerely,

James D. Carade

for James J. McKevitt
Field Supervisor

United States Department of the Interior

FISH AND WILDLIFE SERVICE

SACRAMENTO ENDANGERED SPECIES OFFICE
2800 Cottage Way, Room E-1823
Sacramento, California 95825-1846

22 January 1986

Mr. Walter Yep, Chief
Planning Division
U.S. Army Corps of Engineers
650 Capitol Mall
Sacramento, California 95814

Subject: Potential Repair and Support of Cache and Shag Slough Levees, Solano County (Case No. 1-1-86-SP-123)

Dear Mr. Yep:

This responds to the letter from your agency dated 3 January 1986 requesting a list of endangered and threatened species and those proposed for listing that may be present within the subject project area. This fulfills the requirement of the Fish and Wildlife Service to provide information on listed species pursuant to Section 7(c) of the Endangered Species Act of 1973, as amended.

To the best of our knowledge, there are no listed or proposed threatened or endangered species within the project area. However, we are attaching a list of candidates which might, within the foreseeable future, be proposed and then undergo a final rulemaking. We urge that you consider informal consultation to avoid any conflicts at a later date should the species become listed and be present within the area of the proposal. Informal consultation should be requested of our office at the letterhead address.

Should you have additional questions regarding this list or your responsibilities under the Act, please contact Dr. Jack Williams at (916) 978-4866 or FTS 460-4866. Thank you for your interest in endangered species.

Sincerely yours,

Gail C. Kobetich

Gail C. Kobetich
Project Leader

Attachments

Attch 2

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES THAT MAY OCCUR IN THE AREA OF THE PROPOSED REPAIR AND SUPPORT OF CACHE AND SHAG SLOUGH LEVEES SOLANO COUNTY (Case No. 1-1-86-SP-123)

Listed Species

None

Proposed Species

None

Candidate Species

Reptiles and Amphibians

California tiger salamander, Ambystoma tigrinum californiense (2)
Giant garter snake, Thamnophis couchi gigas (2)

Plants

California hibiscus, Hibiscus californicus (2)
Delta-tule pea, Lathyrus jepsonii subsp. jepsonii (2)
Mason's lilaeopsis, Lilaeopsis masonii (2)

(E)--Endangered (T)--Threatened (CH)--Critical Habitat
(1)--Category 1: Taxa for which the Fish and Wildlife Service has sufficient biological information to support a proposal to list as endangered or threatened.

cc:
Chief, Endangered Species, Portland, OR (AFA-SE; Attn: R. Swanson)
Field Supervisor, Ecological Services, Sacramento, CA (ES-S)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
SACRAMENTO ENDANGERED SPECIES OFFICE
2800 Cottage Way, Room E-1823
Sacramento, California 95825-1846

APR 07 1986

Colonel Wayne J. Scholl
Sacramento District
Corps of Engineers
650 Capitol Mall
Sacramento, California 95814-4974

Subject: Comments on Environmental Assessment for the Cache Slough-Yolo Bypass Levees, Sacramento River Flood Control Project (Case No. 1-1-86-I-255)

Dear Colonel Scholl:

In response to your letter of March 15, 1986, we are providing the following comments on the Environmental Assessment (EA) for the Cache Slough-Yolo Bypass Levees, which is part of the Sacramento River Flood Control Project. As we indicated in our earlier letter of January 22, 1986, the proposed project will not affect any listed or proposed endangered or threatened species.

The project, however, may impact three candidate plants that grow in association with levee or river banks in the Sacramento-San Joaquin River delta. These plants are the California hibiscus (Hibiscus californicus), delta tule-pea (Lathyrus jepsonii var. jepsonii), and Mason's lilaeopsis (Lilaeopsis masonii). We strongly disagree with the EA that asserts, if any of these candidate species are present, project effects "would vary from minor short term impact to beneficial impact". Levee repair and maintenance are the primary activities that threaten these plants. These activities certainly do not provide a "beneficial impact" to these taxa. Moreover, no data exist that confirm the assertion that such repair and maintenance activities only adversely affect these candidates for a "minor short term".

Timely and appropriate floristic work are needed to determine whether any of these three plants are within the project area. If these plants are present, we will gladly determine at that time whether the project will affect the hibiscus, tule-pea, and/or lilaeopsis.

Attch 3

Questions regarding this letter should be addressed to Jim Bartel at (916) 978-4866 or (FTS) 460-4866.

Sincerely yours,

David L Harlow

for Gail C. Kobetich
Project Leader

cc: Field Supervisor, Ecological Services, Sacramento, CA (ES-S)
Chief, Endangered Species, Portland, OR (AFA-SE)

Resources Building
1416 Ninth Street
95814
(916) 445-5656
TDD (916) 324-0804

California Conservation Corps
Department of Boating and Waterways
Department of Conservation
Department of Fish and Game
Department of Forestry
Department of Parks and Recreation
Department of Water Resources

GEORGE DEUKMEJIAN
GOVERNOR OF
CALIFORNIA

THE RESOURCES AGENCY OF CALIFORNIA
SACRAMENTO, CALIFORNIA

Air Resources Board
California Coastal Commission
California Tahoe Conservancy
California Waste Management Board
Colorado River Board
Energy Resources Conservation And Development Commission
San Francisco Bay Conservation and Development Commission
State Coastal Conservancy
State Lands Division
State Reclamation Board
State Water Resources Control Board
Regional Water Quality Control Boards

APR 24 1986

Colonel Wayne Scholl
Army Corps of Engineers
650 Capitol Mall
Sacramento, CA 95814

Dear Colonel Scholl:

The State has reviewed the environmental assessment and draft FONSI, Cache Slough - Yolo Bypass Levees, Sacramento River Flood Control Project, submitted through the Office of Planning and Research. Review was coordinated with the Regional Water Quality Control Board and the Departments of Boating and Waterways, Conservation, Fish and Game, Parks and Recreation, Water Resources, and Health Services.

The Department of Fish and Game concurs in the recommendations of the Fish and Wildlife Service, as contained in the Service's letter of December 19, 1985:

1. The report of the District Engineer, Corps of Engineers, include the conservation and development of fish and wildlife resources among the purposes for which the project is to be undertaken.

2. The planting program described in the Discussion Section be implemented as a project cost.

Questions regarding these comments should be directed to Paul Jensen, Regional Manager, Department of Fish and Game, 1701 Nimbus Road, Rancho Cordova 95670 or (916) 355-0922.

Thank you for providing an opportunity to review this document.

Sincerely,

Gordon F. Snow

Gordon F. Snow, Ph.D.
Assistant Secretary for Resources

cc: Office of Planning and Research
(SCH 86031811)

Attch 4

NATIVE AMERICAN HERITAGE COMMISSION
915 Capitol Mall, Room 288
Sacramento, California 95814

(916) 322-7791

29 April 1986

Wayne Schol
U. S. Corps of Engineers
650 Capitol Mall
Sacramento, CA 95814

Re: Cache Slough-Yolo Bypass
SCH #86031811

Dear Mr. Schol:

Enclosed, please find a list(s) referencing the Commissioner for your region and the Native Americans from whom you may seek advice, guidance, and consultation regarding the cultural resources contained within the subject property, as well as the potential for religious sensitivity of said property.

The preservation and protection of areas maintaining religious and cultural value for California's Native Americans is the responsibility of the Native American Heritage Commission, pursuant to the Public Resources Code Section 5097.9 et seq. This mandate includes a provision for assistance to Native Americans when human remains are at issue, Section 5097.94 (k). Additionally, and in accordance with the Health and Safety Code Section 7050.5, a representative of the Coroner's office must be notified when human remains are located during any and all phases of a project. If the remains are determined to be of Native American origin, the Commission must be informed, whereupon we will assist, in a timely and dignified fashion, in the protection and preservation of the inhumations/cremations and associated grave goods.

The Commission extends its appreciation in affording us the opportunity for expression of concern and opinion relative to your project. Please be advised that the enclosure(s) is provided as a measure for ensuring that the concerns of the local Native American community are addressed and, therefore, is not for public disclosure.

Please, if you have any questions do not hesitate to call.

Respectfully yours,

R. Paige Talley

R. Paige Talley
Special Assistant

Enclosure(s)
RPT:gt

COUNTY REFERRAL LIST

NAME, ADDRESS TELEPHONE NO.	TRIBAL AFFILIATION	AREA(S)	B	C	R	S	W	OTHER
Karl Mathiesen P.O.Box 85 Jamestown, CA 95327 (209) 984-0324	MIWOK							
3/86 Suskol Indian Council Norma Knight 1187 Yakayo Ranch Road Ukiah, CA 95482 To contact her by phone: Mira Knight (daughter) DQ University 916-758-0470 or Lois Whipple (daughter) (707) 983-6248	POMO(Southern)							
Fred Downey (Coyote) c/o DQ University 916-758-0470 (3/86)								

KEY:

B: Burial place/Cemetery
C: Collection Area
R: Rock art (picto., petro., intaglio, etc.)
S: Sacred/Power area
W: Worship/Ritual area

Priscilla Hunter, Commission Member
P.O. Box 73
Redwood Valley, CA 95470

Ada Merhoff
P.O. Box 960
Davis, CA-95617

March 27, 1986

Army Corps of Engineers
650 Capitol Mall
Sacramento, CA-95814

Re: Cache - Yolo Project
Case No 1-1-86-I-255

I represent the Mother Lode Chapter of the Sierra Club--Yolano Group. I think it obvious that protection of Liberty Island justifies the work proposed, and it appears from the EA that there will be only moderate environmental impact.

I will stress the importance of the reestablishment of natural vegetation along the berm of the new levee. Requiring ten years to completely restore that environment, this work will require on-goingmaintenance and restoration of damaged areas as they occur. Wildlife appropriate to whatever habitat emerges will again become established, be it wet lands or agrarian.

The Sierra Club thanks you for informing us of this project.

Sincerely,

Ada Merhoff

Attch. 6

February 14, 1986

Environmental Resources Branch

Mr. James J. McKevitt
Field Supervisor
Ecological Services
Fish and Wildlife Service
2800 Cottage Way, Room E-1803
Sacramento, California 95828

Dear Mr. McKevitt:

This responds to the recommendations contained in your December 19, 1985 planning aid letter (PAL) for the Sacramento River Flood Control project (Cache Slough-Yolo Bypass) in Solano County, California. We concur with your recommendation to reseed disturbed areas with native grasses.

Since receiving your PAL, design has been proceeding. Please note the following changes to the data furnished ~~your~~ previously. The project alternatives covered in your PAL have been reduced to a single recommended plan which is the cross-levee plan described as Alternative No. 3. The existing levees which will remain north of the cross-levee will not be widened as described in your PAL. Localized areas of the levee will be filled, and the entire crown of the levee will be reshaped. This means that there will not be a waterside berm on these levees and that only vegetation on the crown of the levee, which is not occupied by a road, and in the areas where fill is needed to repair subsidence will be disturbed. It does not appear that these changes require a change in your PAL.

We are unable to concur with recommendation No. 1, that conservation and development of fish and wildlife resources be included among the purposes for which the project is to be authorized. The work planned is to complete the construction of the Cache Slough-Yolo Bypass levee under the Sacramento River Flood Control project. No new authorization is being sought.

If you have any questions concerning the above, please contact Mr. Ram Kalia at (916) 551-2046.

Sincerely,

Albert E. McCollam, Jr.
Lieutenant Colonel, Corps of Engineer
Acting District Engineer

Attch 7

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO CALIFORNIA 95814 4794

REPLY TO
ATTENTION OF

March 14, 1986

Environmental Resources Branch

NOTICE OF AVAILABILITY

Environmental Assessment
Draft Finding Of No Significant Impact
for
Cache Slough-Yolo Bypass Levees,
Sacramento River Flood Control Project

Copies of the environmental assessment (EA), and the draft finding of no significant impact (FONSI), for the Cache Slough-Yolo Bypass Levees, Sacramento River Flood Control Project (SRFCP), are available for review at the following locations:

U.S. Army Corps of Engineers Sacramento District 545 Downtown Plaza, Room 250 Sacramento, CA. 95814	Yolo County Public Library Davis Branch 315 East 14th Street Davis, CA 95616

The Corps of Engineers proposes to conduct the work described below in cooperation with the California State Reclamation Board which is the non-Federal sponsor of the SRFCP. The work to be performed on the project is the completion of the levee at the junction of Cache and Shag Sloughs at the lower end of the Yolo Bypass. This work consists of constructing a cross levee from Cache Slough to Shag Slough and repairing the existing levees north of the cross levee. The purpose of the project is to complete construction of the flood control levees to minimize levee slips and subsidence, restore adequate freeboard, and provide flood protection to 13,000 acres of agricultural land together with public roads and related homes and buildings in Solano County. An environmental impact statement (EIS) was not prepared for the SRFCP because construction was prior to 1964. The environmental assessment has been prepared to determine whether the environmental impacts associated with completing the work at the Cache Slough-Yolo Bypass location will be significant enough to require the preparation of an EIS at this time. The EA and draft FONSI present information and a tentative conclusion that no EIS is necessary. Comments on the draft FONSI received by 15 April 1986 will be considered during finalization of the document. Copies of the EA and draft FONSI may be obtained by writing to the Corps of Engineers, SPKPD-R, 650 Capitol Mall, Sacramento, CA 95814 or by contacting Mike Welsh at (916) 551-1861.

Sincerely,

Wayne J. Scholl
Colonel, Corps of Engineers
District Engineer

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814-4794

REPLY TO
ATTENTION OF

D-R-A-F-T

FINDING OF NO SIGNIFICANT IMPACT (FONSI) CACHE SLOUGH-YOLO BYPASS LEVEES, SACRAMENTO RIVER FLOOD CONTROL PROJECT

1. I have reviewed and evaluated information presented in the environmental assessment, other documents concerning the Cache Slough-Yolo Bypass Levee area in Solano County, and views of other agencies, organizations, and individuals on environmental impacts for the proposed project. The currently recommended project is designed to solve the levee subsidence and related flooding problem by building a cross levee to connect the Cache Slough levee with the Shag Slough levee, and rebuilding the existing levees north of the cross levee.

2. The possible consequences of the alternatives have been studied with consideration given to environmental, social well-being, and economic and engineering feasibility. The environmental impacts of the project which will be fully mitigated for include loss of small amounts of grassland and riparian vegetation. We have coordinated with the U.S. Fish and Wildlife Service, National Park Service, National Marine Fisheries Service, and the following State Agencies: Resources Agency, Department of Water Resources, Reclamation Board, Department of Fish and Game, and State Historical Preservation Officer.

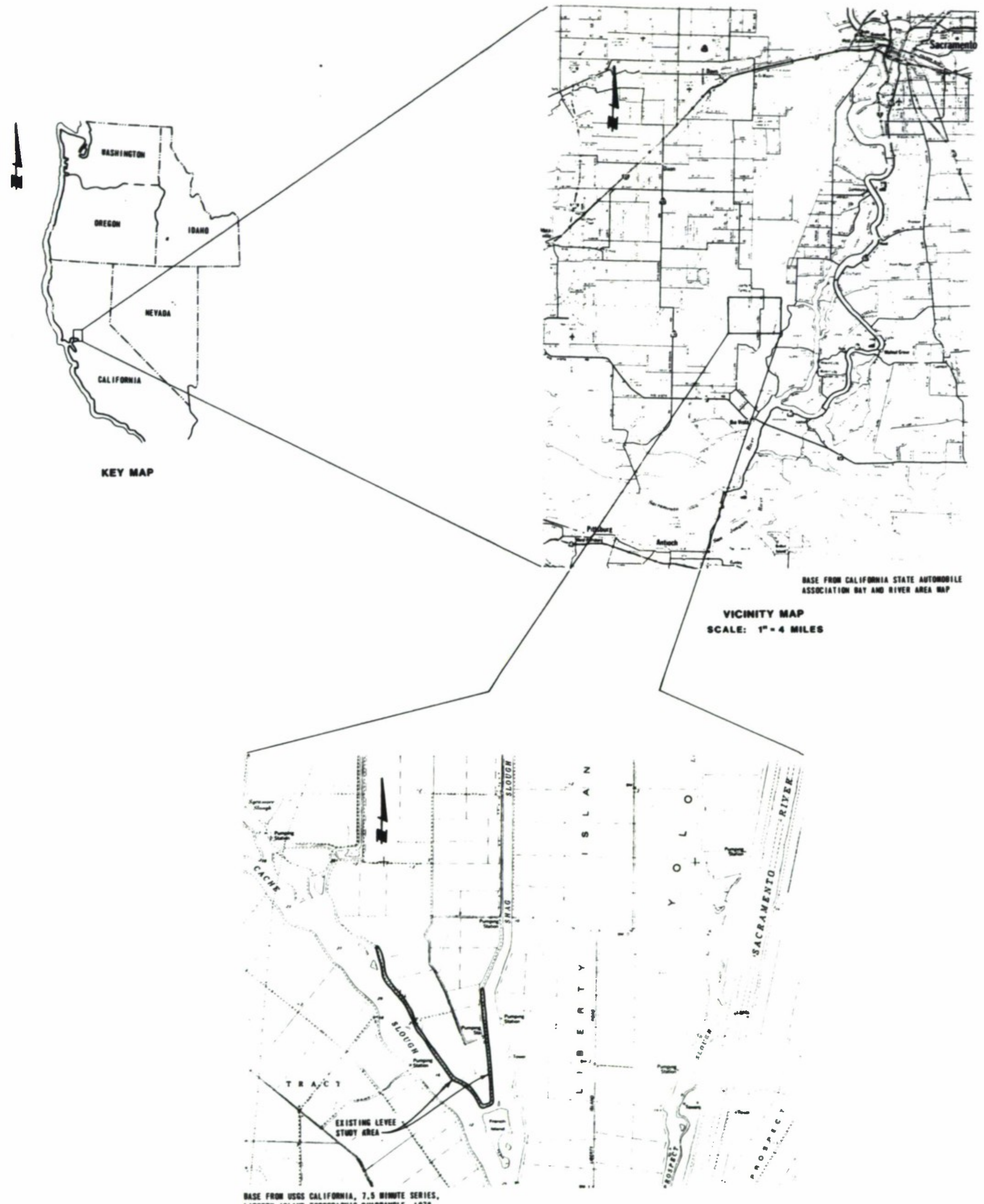
3. Based on my knowledge of the project area and the considerations cited above, I have determined that construction of the cross levee and stablizing the existing levees is the most logical and desirable plan of action. This would restore flood protection sought when this portion of the Sacramento River Flood Control Project was constructed many years earlier. Specific considerations of environmental factors led to the conclusion there would be no significant impacts on natural vegetation and associated wildlife resources. The overall impact on the environment would be insignificant. Therefore, an environmental assessment and EONSI will provide adequate environmental documentation. The public interest will be best served by constructing these remaining measures for flood protection that will complete this project.

*

Date

*
____
Wayne J. Scholl
Colonel, Corps of Engineers
District Engineer

* - To be signed and dated upon completion of the coordination of the Environmental Assessment.



KEY MAP

VICINITY MAP
SCALE: 1" = 4 MILES

BASE FROM CALIFORNIA STATE AUTOMOBILE ASSOCIATION BAY AND RIVER AREA MAP

BASE FROM USGS CALIFORNIA, 7.5 MINUTE SERIES, LIBERTY ISLAND TOPOGRAPHIC QUADRANGLE, 1978.

SITE PLAN
SCALE: 1" = 2000'

INDEX OF DRAWINGS

SHEET NO.		DRAWING TITLE
1	EXISTING LEVEES INVESTIGATION	SITE PLAN AND INDEX OF DRAWINGS
2		LOCATION OF EXPLORATIONS
3		LOGS OF BORINGS - PREVIOUS INVESTIGATIONS
4		LOGS OF BORINGS - PREVIOUS INVESTIGATIONS
5		LOGS OF BORINGS
6		LOGS OF BORINGS
7		LOGS OF FIELD VANE BORINGS
8		LEVEE AND FOUNDATION PROFILE
9		SUMMARY OF LABORATORY TEST RESULTS
10		SUMMARY OF LABORATORY TEST RESULTS
11		SUMMARY OF LABORATORY TEST RESULTS
12	BORROW INVESTIGATION	LOGS OF BORINGS
13		SUMMARY OF LABORATORY TEST RESULTS
14	EXISTING LEVEE REPAIR DESIGN	PLAN
15		PROFILE
16		SECTIONS AND DETAILS
17		STABILITY ANALYSES RESULTS
18	CROSS LEVEE DESIGN	PLAN
19		PROFILE
20		SECTIONS AND DETAILS
21		STABILITY ANALYSES RESULTS

SCALES
4 0 4 MILES
2000 0 2000 FEET

REVISIONS	DATE	DESCRIPTION	BY	BY

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

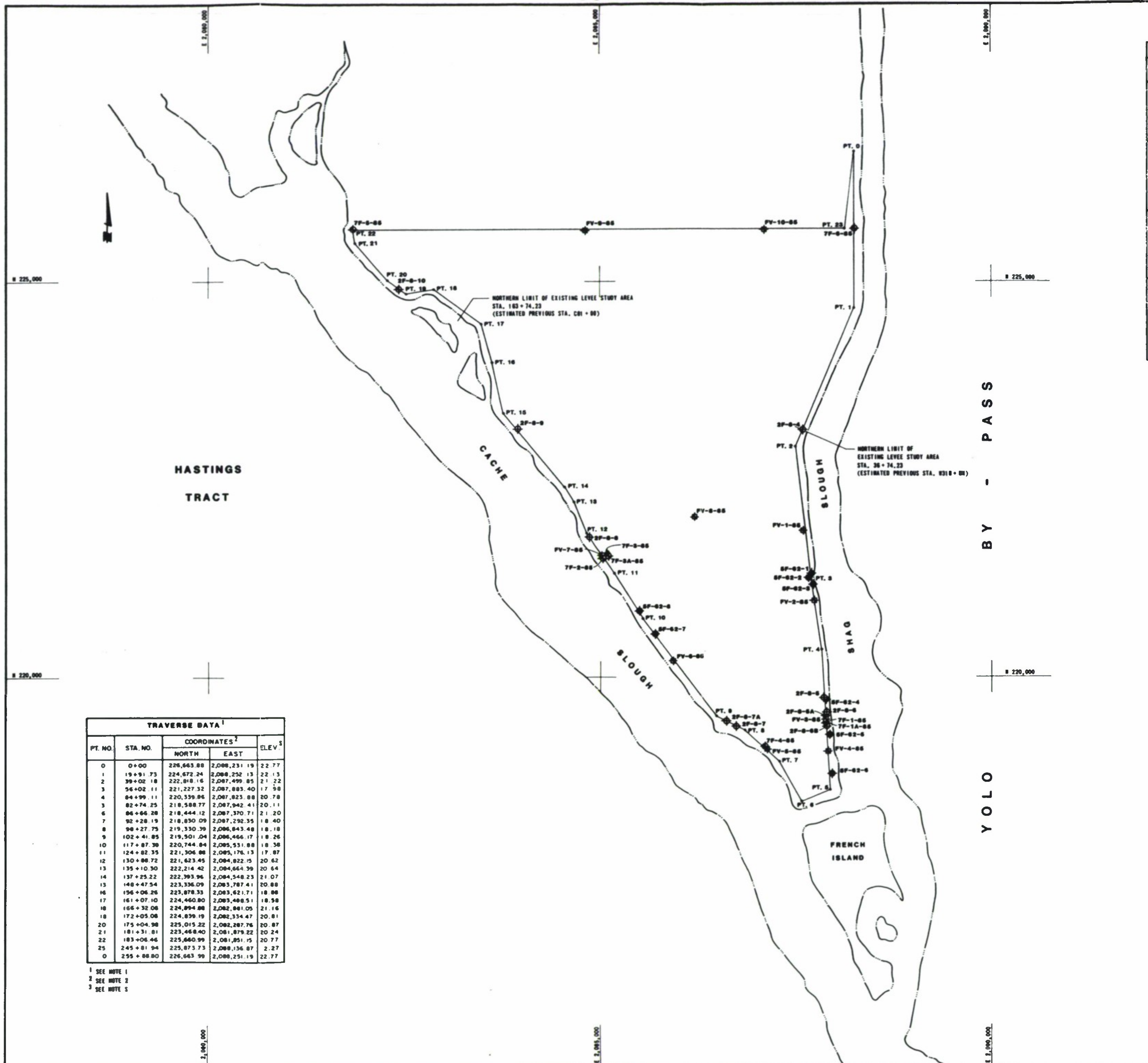
DESIGNED: S. R. KLINE
DRAWN: R. T. TARCZY
CHECKED: C. R. PERRY

CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES

SITE PLAN AND INDEX OF DRAWINGS

SUBMITTED: [signature] DATE APPROVED: SCALE: SPEC. No. SHEET 1/21 FILE No. 50-10-5757

PLATE 1



BORING LOCATION DATA

SYMBOL	HOLE NUMBER	COORDINATES[1] NORTH	EAST
◆	2F-8-4	223,123	2,087,500
	2F-8-5	219,730	2,087,853
	2F-8-6	219,500	2,087,886
	2F-8-7	219,071	2,086,730
	2F-8-8	221,706	2,086,962
	2F-8-9	223,121	2,083,854
	2F-8-10	224,808	2,082,432
◆	SF-62-1	221,318	2,087,218
	SF-62-2	221,256	2,087,872
	SF-62-3	221,107	2,087,730
	SF-62-4	215,214	2,087,808
	SF-62-5	219,206	2,087,828
	SF-62-6	219,770	2,087,858
	SF-62-7	220,545	2,086,082
	SF-62-8	220,835	2,086,408
◆	7F-1-85	219,441	2,087,873
	7F-1A-85	219,434	2,087,874
	7F-2-85	221,408	2,085,826
	7F-3-85	221,532	2,085,886
	7F-3A-85	221,529	2,085,888
	7F-4-85	219,114	2,087,114
	7F-5-85	225,053	2,081,855
	7F-6-85	225,064	2,088,282
◆	FV-1-85	221,858	2,087,888
	FV-2-85	220,864	2,087,741
	FV-3-85	219,488	2,087,872
	FV-4-85	219,887	2,087,864
	FV-5-85	219,118	2,087,134
	FV-6-85	220,283	2,085,822
	FV-7-85	221,325	2,085,821
	FV-8-85	222,822	2,086,212
	FV-9-85	225,647	2,088,818
	FV-10-85	225,853	2,087,118

[1] SEE NOTES 2, 4, AND 5.

LEGEND

SACRAMENTO DISTRICT CORPS OF ENGINEERS PREVIOUS INVESTIGATIONS

- ◆ BORING LOCATION (1958 INVESTIGATION)
- ◆ BORING LOCATION (1962 INVESTIGATION)

WAHLER ASSOCIATES INVESTIGATION (FEBRUARY - MARCH, 1985)

- ◆ BORING LOCATION
- ◆ FIELD VANE BORING LOCATION

NOTES:

1. TRAVERSE DATA IS FROM SACRAMENTO DISTRICT CORPS OF ENGINEERS TRAVERSE, PROFILE, AND CROSS SECTION LOCALITY MAP, SHEET 1, FILE NO. 50-13-5720.
2. GRID COORDINATES REFER TO CALIFORNIA STATE COORDINATE SYSTEM, ZONE II.
3. TRAVERSE POINT ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929.
4. COORDINATES OF BORING LOCATIONS FROM SACRAMENTO DISTRICT CORPS OF ENGINEERS PREVIOUS INVESTIGATIONS ARE FROM THE FIELD BORING LOGS WHICH INDICATED THEY WERE SCALED. NO DATA WAS AVAILABLE FOR THE COORDINATE LOCATIONS OF BORINGS 2F-8-6A, 2F-8-8B, AND 2F-8-7A; THE LOCATIONS OF THESE HOLES ARE ESTIMATED FROM A PREVIOUSLY DEVELOPED PROFILE INDICATING LOGS OF BORINGS FROM THE 1958 AND 1962 INVESTIGATIONS.
5. COORDINATES OF BORING LOCATIONS FROM WAHLER ASSOCIATES INVESTIGATIONS ARE SCALED FROM DETERMINED LOCATIONS ON TOPOGRAPHIC MAPS. THE BORING LOCATIONS WERE REFERENCED IN THE FIELD BY TAPING FROM TRAVERSE POINTS.

SCALE

500 0 500 FEET

TRAVERSE DATA[1]

PT. NO.	STA. NO.	COORDINATES[2] NORTH	EAST	ELEV.[3]
0	0+00	226,663.88	2,088,231.19	22.77
1	19+91.73	224,672.24	2,088,252.13	22.13
2	39+02.18	222,818.16	2,087,499.85	21.22
3	56+02.11	221,227.32	2,087,883.40	17.98
4	84+99.11	220,339.86	2,087,823.88	20.78
5	82+74.25	218,588.77	2,087,942.41	20.11
6	86+66.28	218,444.12	2,087,370.71	21.20
7	92+28.19	218,830.09	2,087,292.35	18.40
8	98+27.75	219,330.39	2,086,843.48	18.18
9	102+41.85	219,501.04	2,086,466.17	18.26
10	117+87.38	220,744.84	2,085,531.88	18.38
11	124+82.35	221,306.88	2,085,176.13	17.87
12	130+88.72	221,623.45	2,084,822.15	20.62
13	135+10.30	222,214.42	2,084,664.39	20.64
14	137+25.22	222,393.96	2,084,548.23	21.07
15	148+47.54	223,336.09	2,083,787.41	20.88
16	156+06.26	223,878.33	2,083,621.71	18.88
17	161+07.10	224,460.80	2,083,488.51	18.58
18	166+32.08	224,894.88	2,082,881.05	21.16
19	172+05.08	224,839.19	2,082,334.47	20.81
20	175+04.98	225,015.22	2,082,287.76	20.87
21	181+31.81	223,468.40	2,081,879.22	20.24
22	183+06.46	225,660.99	2,081,851.15	20.77
25	245+81.94	225,873.73	2,088,136.87	2.27
0	255+88.80	226,663.99	2,088,251.19	22.77

[1] SEE NOTE 1
[2] SEE NOTE 2
[3] SEE NOTE 3

REVISION	DATE	DESCRIPTION	BY	BY

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

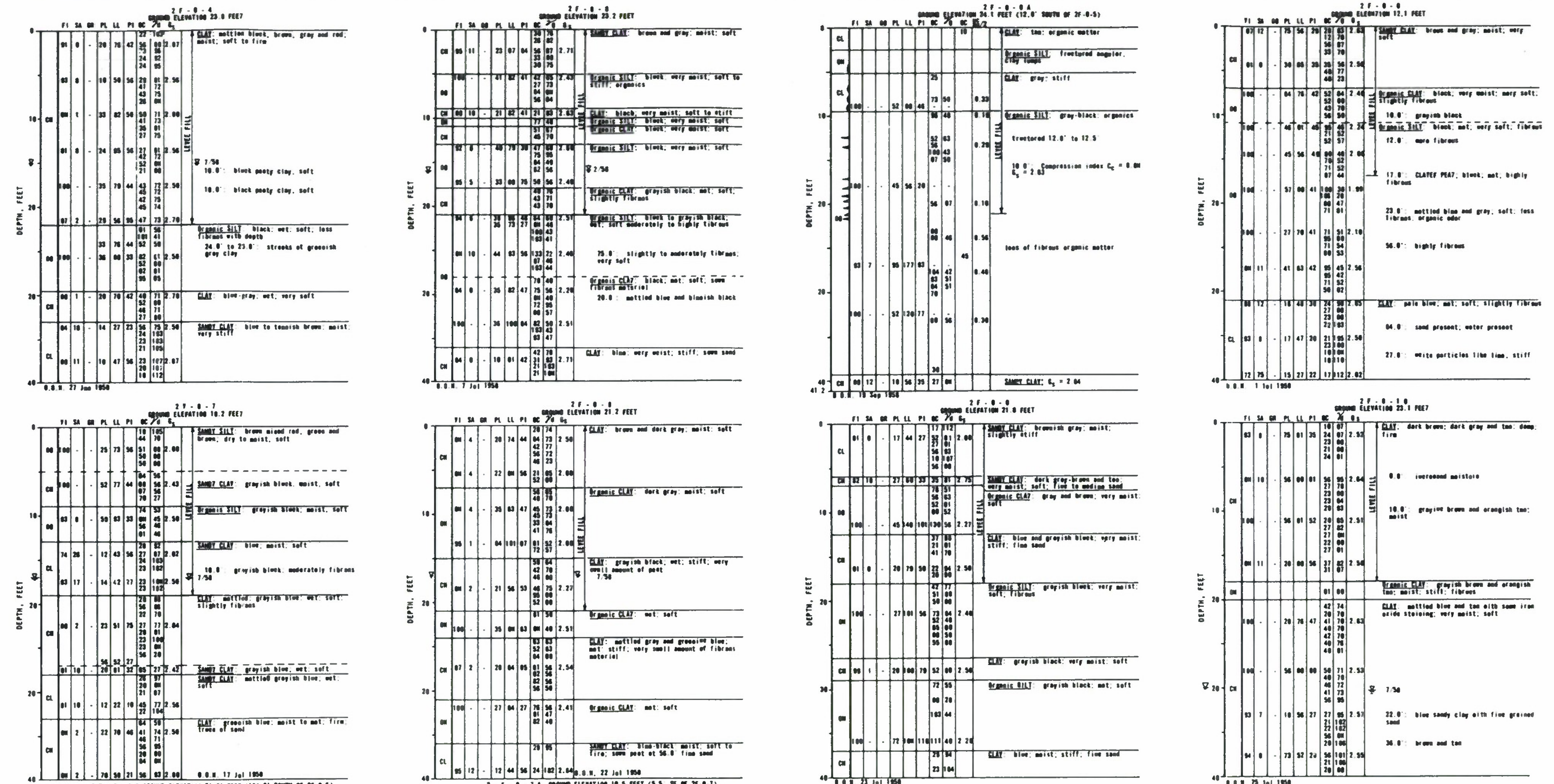
DESIGNED: S. R. KLINE
DRAWN: B. T. TARCZY
CHECKED: C. B. PERRY

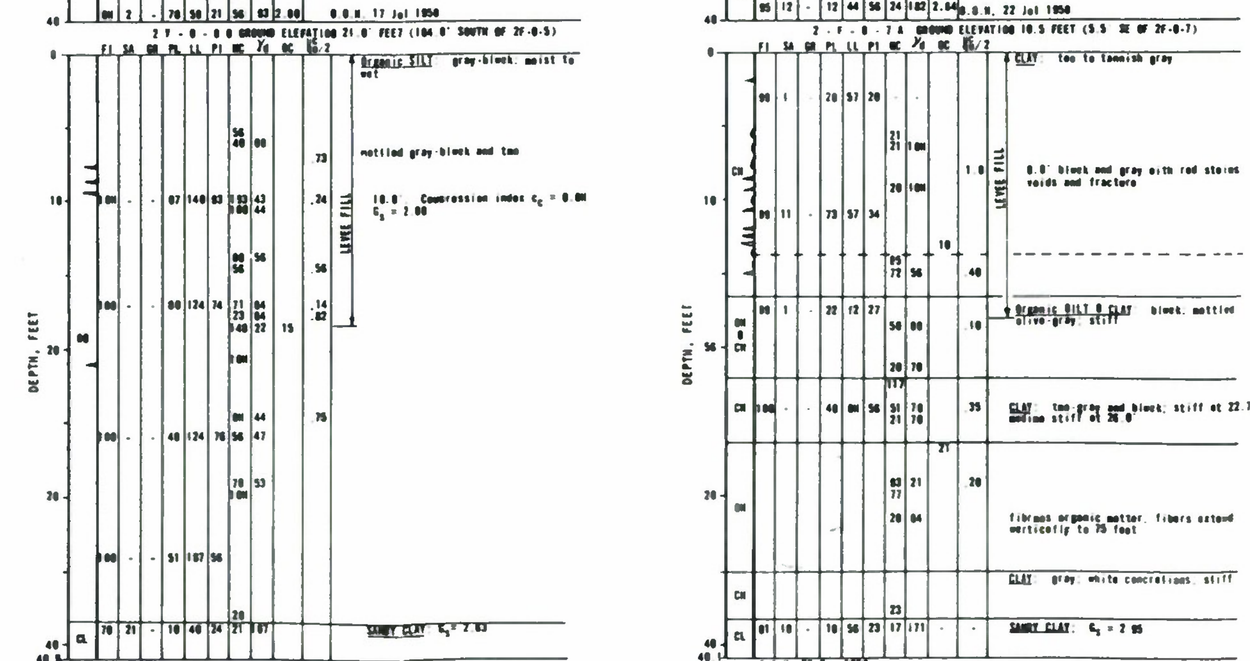
CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
EXISTING LEVEES INVESTIGATION
LOCATION OF EXPLORATIONS

SUBMITTED: Norman T. Platt
DATE APPROVED:
SCALE:
SPEC. No.
SHEET 2/21
FILE No. 50-10-5757

PLATE 2

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING





LEGEND:

- FI — FINES, PERCENT BY WEIGHT PASSING THE NO. 200 SIEVE.
- SA — SAND, PERCENT BY WEIGHT PASSING THE NO. 4 SIEVE AND RETAINED ON THE NO. 200 SIEVE.
- GR — GRAVEL, PERCENT BY WEIGHT PASSING THE 2-INCH SIEVE AND RETAINED ON THE NO. 4 SIEVE.
- PL — PLASTIC LIMIT, PERCENT.
- LL — LIQUID LIMIT, PERCENT.
- PI — PLASTICITY INDEX (LL-PL), PERCENT.
- MC — FIELD MOISTURE CONTENT, PERCENT OF DRY WEIGHT.
- γ_d — FIELD DRY DENSITY, PCF.
- G_s — SPECIFIC GRAVITY (MINUS NO. 4 SIEVE MATERIAL).
- OC — ORGANIC CONTENT, PERCENT.
- UC — UNCONFINED COMPRESSION TEST.
- $q_u/2$ — ONE HALF OF THE UNCONFINED COMPRESSIVE STRENGTH, TSF.
- ∇ — MEASURED GROUNDWATER LEVEL.
- 0 — VOID-APPARENTLY FROM DISTURBED SAMPLING.
- FRACTURE.
- SEPARATION.

NOTES:

1. EXPLORATIONS SHOWN ON THIS PLATE WERE DRILLED AND LOGGED BY THE SACRAMENTO DISTRICT, U.S. ARMY CORPS OF ENGINEERS. LOGS REDRAWN 1 THRU 11 OCT 1985.
2. BORINGS 2F-0-4 THRU 2F-0-10 WERE DRILLED WITH AN 8-INCH HOLLOW STEM AUGER (SULLIVAN) BETWEEN 73 JUNE 1950 AND 24 JULY 1950. SAMPLES WERE COLLECTED IN A 2-INCH PUSH TUBE ADVANCED WITH A HYDRAULIC PRESS.
2. BORINGS 2F-0-04, 00 AND 7A WERE DRILLED WITH A SWEDISH FOIL SAMPLER IN SEPTEMBER 1950.
4. SOIL CLASSIFICATIONS ARE IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM-2487).
2. ELEVATIONS REFER TO CORPS OF ENGINEERS DATUM.

REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: K.B.V.
DRAWN: K.B.V., R.A.V.
CHECKED: D.J.A.

CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
EXISTING LEVEES INVESTIGATION

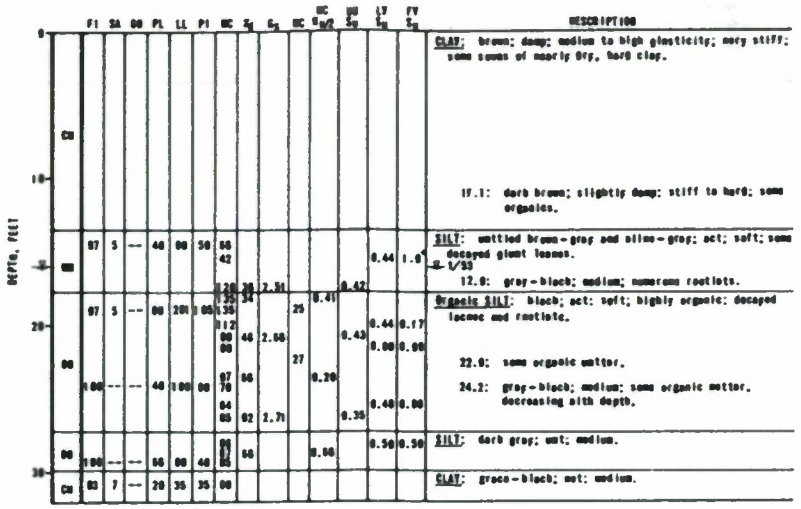
LOGS OF BORINGS - PREVIOUS INVESTGATION

SUBMITTED: CHIEF, SOILS DESIGN SECTION
DATE APPROVED:
SCALE:
SPEC. No.
SHEET 3/21
FILE No. 50-10-5757

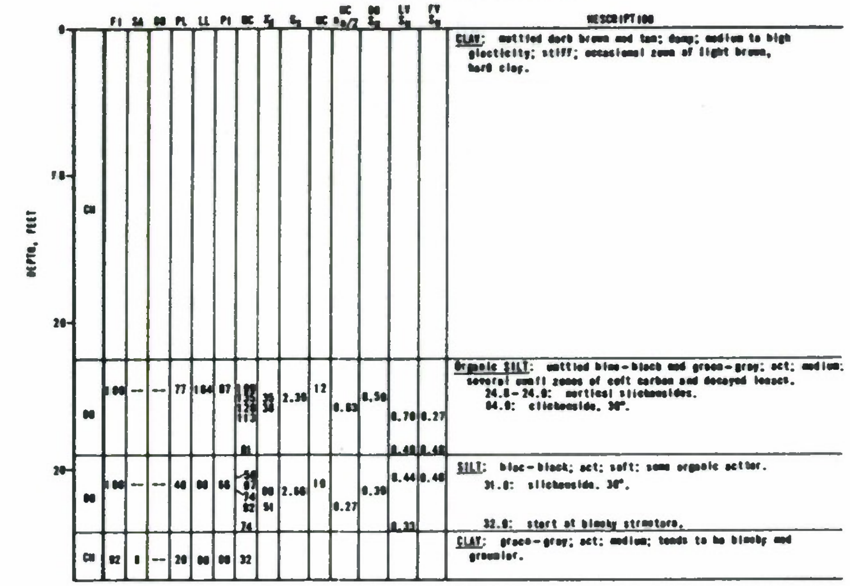
PLATE 3

FUNCTIONAL ANALYSIS - VE PAYS

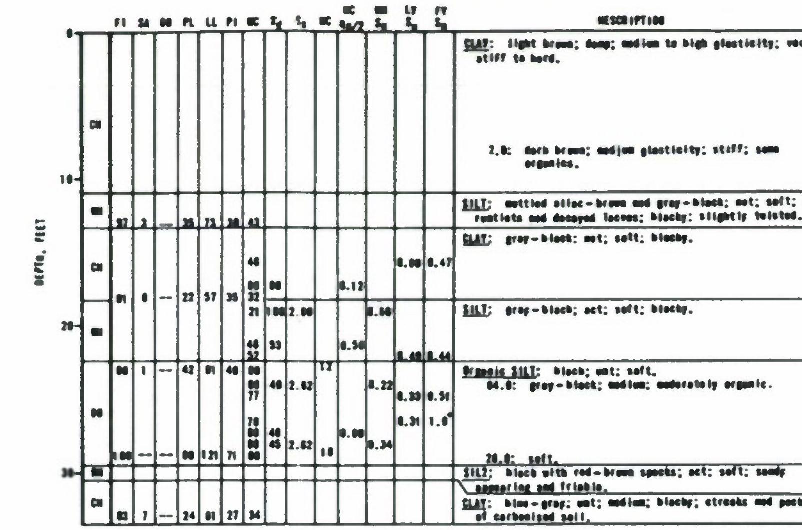
SF-62-1
GROUND ELEVATION 15.6 FEET



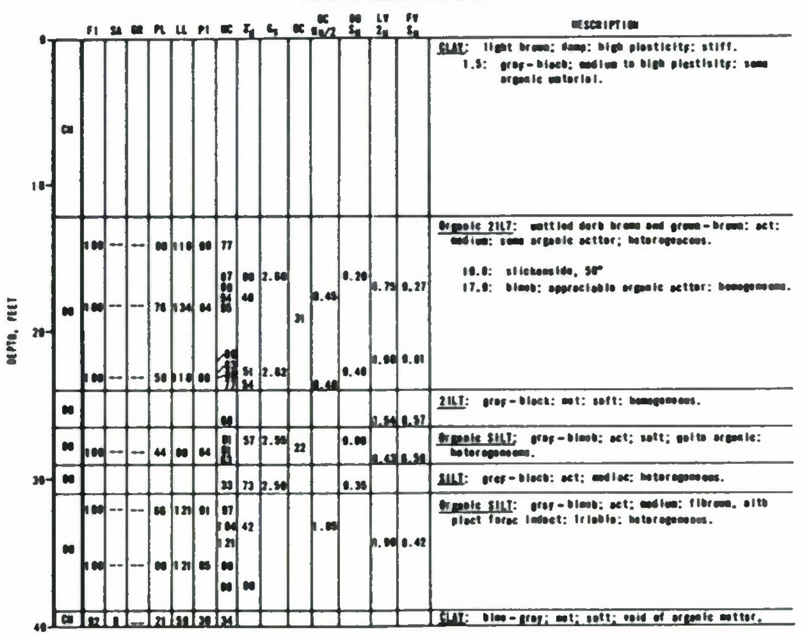
SF-62-2
GROUND ELEVATION 20.4 FEET



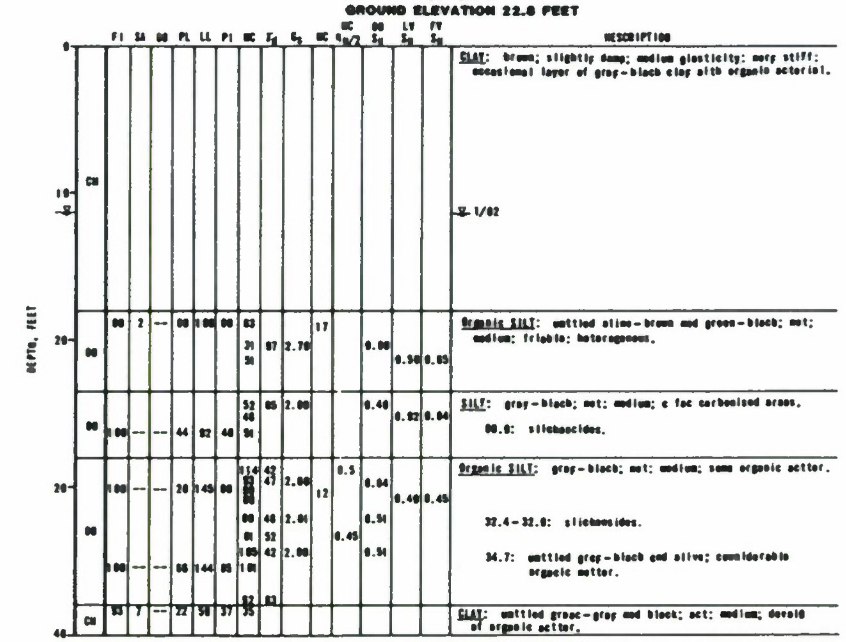
SF-62-3
GROUND ELEVATION 14.8 FEET



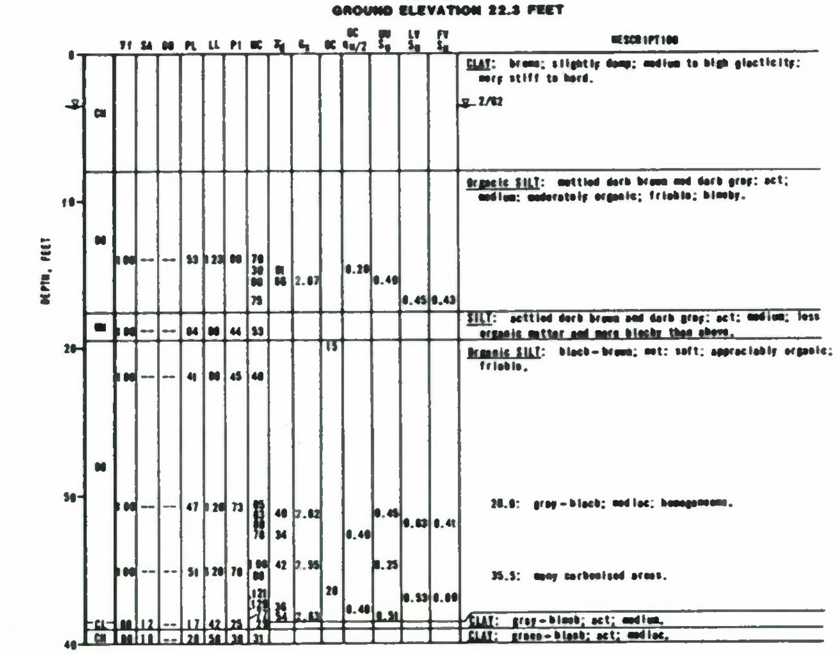
SF-62-4
GROUND ELEVATION 24.3 FEET



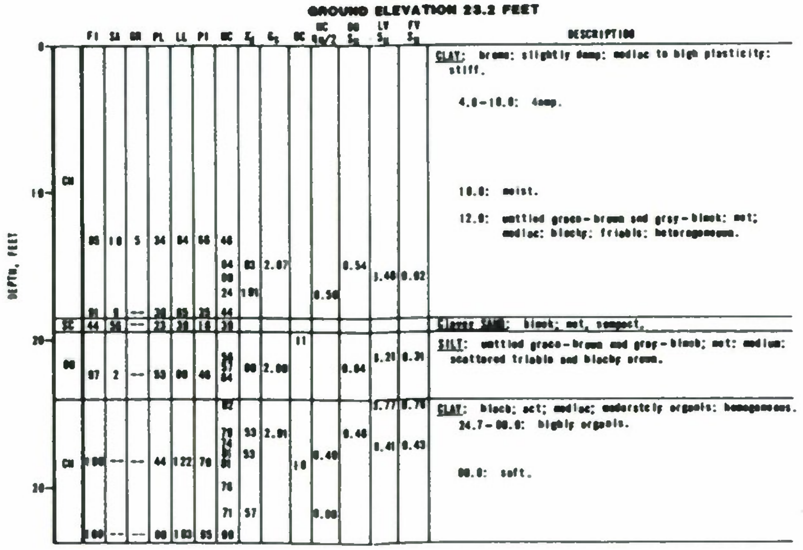
SF-62-5
GROUND ELEVATION 22.8 FEET



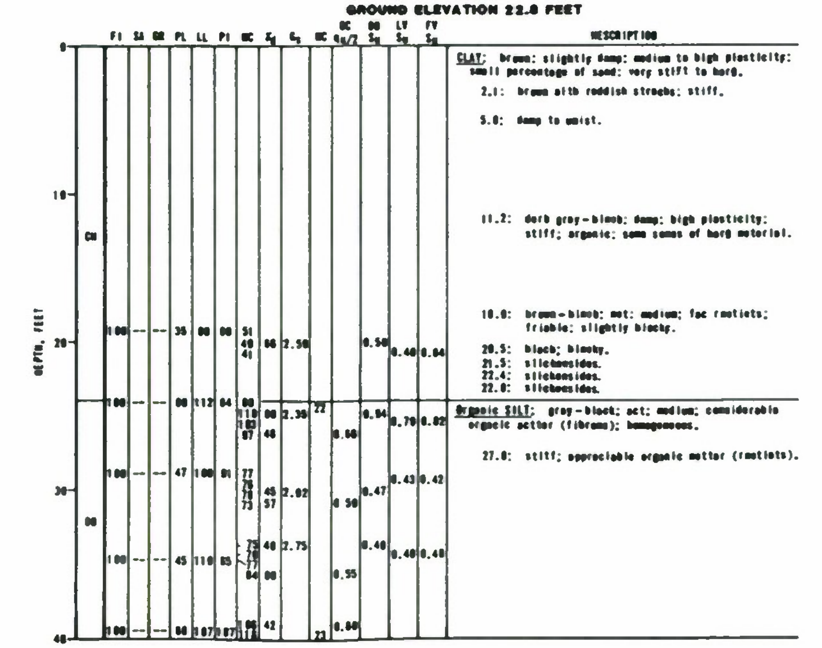
SF-62-6
GROUND ELEVATION 22.3 FEET



SF-62-7
GROUND ELEVATION 23.2 FEET



SF-62-8
GROUND ELEVATION 22.8 FEET



LEGEND

FI	FINES, PERCENT BY WEIGHT PASSING THE NO. 200 SIEVE
SA	SAND, PERCENT BY WEIGHT PASSING THE NO. 4 SIEVE AND RETAINED ON THE NO. 200 SIEVE
GR	GRAVEL, PERCENT BY WEIGHT PASSING THE 3-INCH SIEVE AND RETAINED ON THE NO. 4 SIEVE
PL	PLASTIC LIMIT, PERCENT
LL	LIQUID LIMIT, PERCENT
PI	PLASTICITY INDEX (LL - PL), PERCENT
MC	FIELD MOISTURE CONTENT, PERCENT OF DRY WEIGHT
γ_d	FIELD DRY DENSITY, PCF
G_s	SPECIFIC GRAVITY (MINUS NO. 4 SIEVE MATERIAL)
OC	ORGANIC CONTENT, PERCENT
UC	UNCONFINED COMPRESSION TEST
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
LV	LABORATORY VANE
FV	FIELD VANE
$q_u/2$	ONE HALF OF THE UNCONFINED COMPRESSIVE STRENGTH, TSF
S_u	UNDRAINED SHEAR STRENGTH, TSF
∇	MEASURED GROUNDWATER LEVEL

NOTES:

1. LOGS OF BORINGS ON THIS DRAWING ARE FROM PREVIOUS INVESTIGATIONS BY THE SACRAMENTO DISTRICT U.S. ARMY CORPS OF ENGINEERS. BORINGS DRILLED WITH FAILING 1500 DRILL RIG WITH 6-INCH DIAMETER FLIGHT AUGER AND SAMPLED WITH 4.5-INCH DIAMETER SWEDISH FOIL SAMPLER BETWEEN JANUARY 12, 1982 AND FEBRUARY 5, 1982.
2. THE SOIL CLASSIFICATIONS AND DESCRIPTIONS PRESENTED ON THE LOGS BY WAHLER ASSOCIATES ARE BASED ON LABORATORY MECHANICAL ANALYSES AND ATTERBERG LIMITS, LABORATORY SAMPLE LOG VISUAL CLASSIFICATIONS, AND FIELD LOG VISUAL CLASSIFICATIONS WITH MOST WEIGHT BEING GIVEN TO LABORATORY TESTS AND LABORATORY VISUAL CLASSIFICATIONS.
2. THE LABORATORY TEST RESULTS PRESENTED ON THE LOGS ARE FROM "REPORT OF SOIL TESTS - UNDISTURBED SOIL SAMPLES OBTAINED WITH SWEDISH FOIL SAMPLER - YOLO BYPASS - CACHE SLOUGH LEVEE", MARCH 1982, U.S. ARMY ENGINEER DIVISION LABORATORY - SOUTH PACIFIC, CORPS OF ENGINEERS, SAUSALITO, CALIFORNIA.
4. THE UNDRAINED SHEAR STRENGTH PRESENTED FOR THE UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST DATA IS BASED ON A φ=0 ASSUMPTION.
5. ELEVATIONS REFER TO CORPS OF ENGINEERS DATUM.

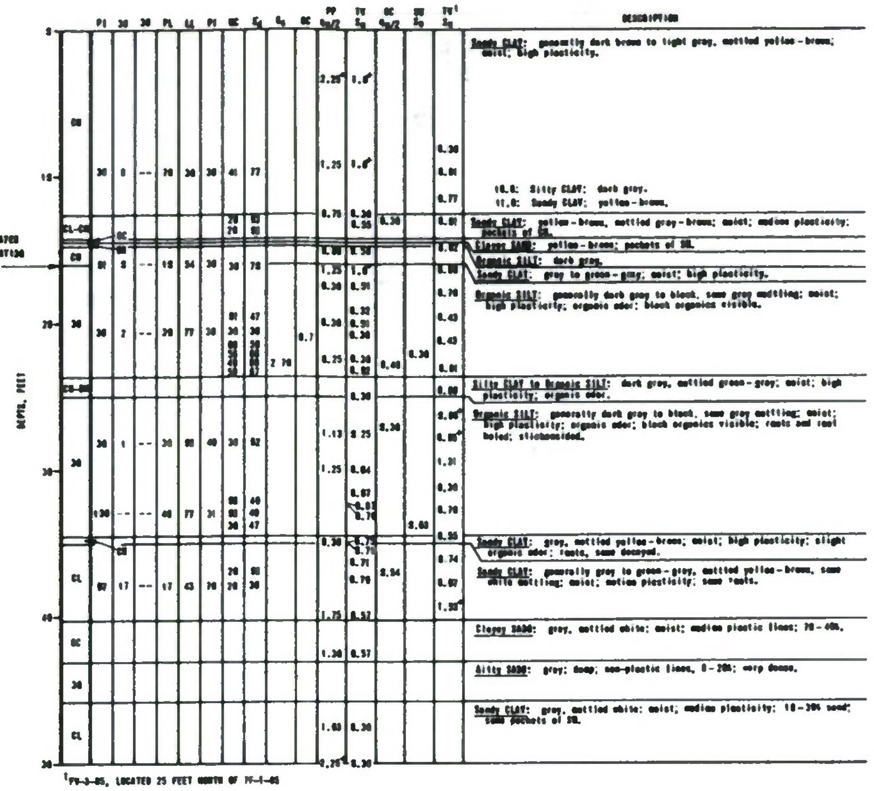
REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

Wahler Associates	DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
DESIGNED: S. H. KLINE DRAWN: H. T. TARCZY CHECKED: C. H. PERRY	CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES EXISTING LEVEES INVESTIGATION LOGS OF BORINGS - PREVIOUS INVESTIGATIONS
SUBMITTED: [signature]	DATE APPROVED:
SCALE:	SPEC. No.
SHEET 4/21	FILE No. 50-10-5757

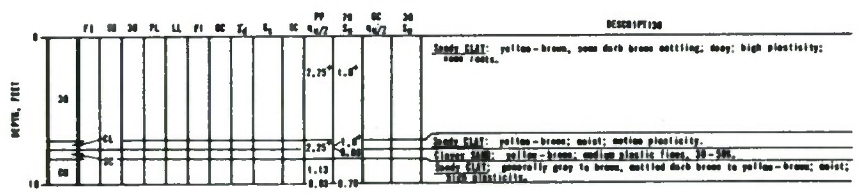
PLATE 4

SAFETY PAYS

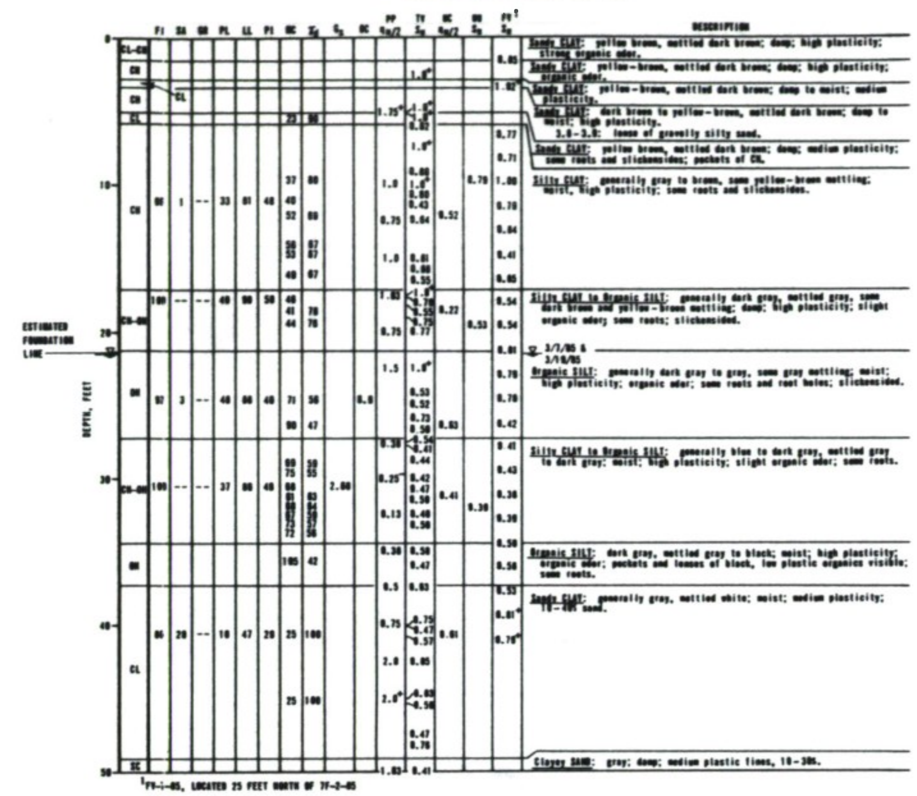
7F-1-85
GROUND ELEVATION 21.0 FEET



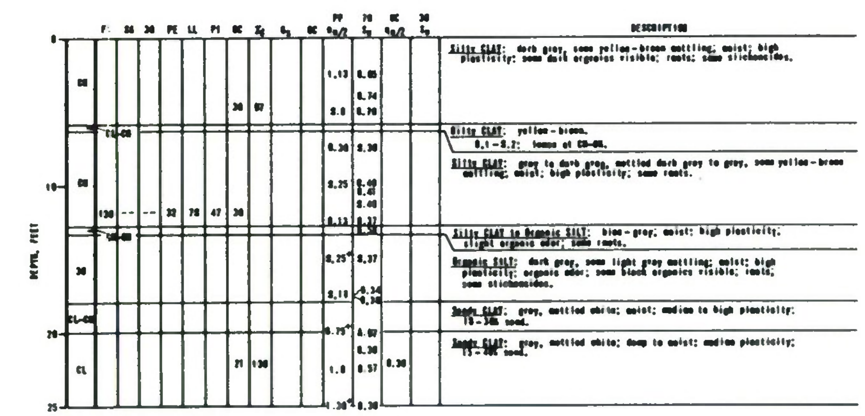
7F-1A-85
GROUND ELEVATION 21.0 FEET



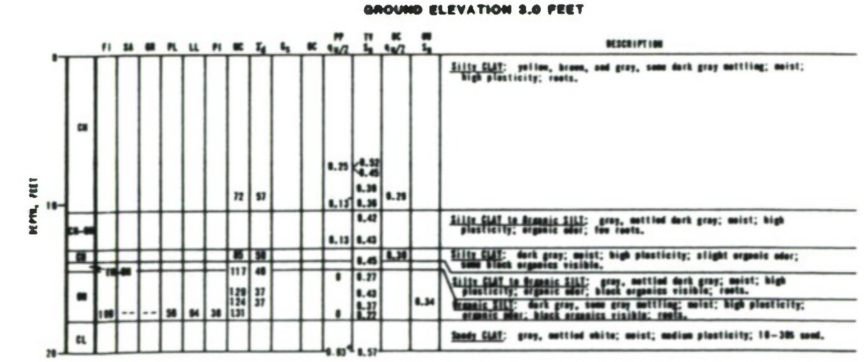
7F-2-85
GROUND ELEVATION 21.7 FEET



7F-3-85
GROUND ELEVATION 3.0 FEET



7F-3A-85
GROUND ELEVATION 3.0 FEET



UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487)

PRIMARY DIVISIONS			GROUP SYMBOL	SECONDARY DIVISIONS
COARSE GRAINED SOILS	GRAVELS	CLEAN GRAVELS	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
			GP	POORLY GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
		GRAVEL WITH FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES, NON-PLASTIC FINES.
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES, PLASTIC FINES.
	SANDS	CLEAN SANDS	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.
			SP	POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.
		SANDS WITH FINES	SM	SILTY SANDS, SAND-SILT MIXTURES, NON-PLASTIC FINES.
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES, PLASTIC FINES.
FINE GRAINED SOILS	SILTS & CLAYS		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY.
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
	SILTS & CLAYS		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS.
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.
HIGHLY ORGANIC SOILS			PT	PEAT AND OTHER HIGHLY ORGANIC SOILS.

LEGEND

- FI — FINES, PERCENT BY WEIGHT PASSING THE NO. 200 SIEVE
- SA — SAND, PERCENT BY WEIGHT PASSING THE NO. 4 SIEVE AND RETAINED ON THE NO. 200 SIEVE
- GR — GRAVEL, PERCENT BY WEIGHT PASSING THE 3-INCH SIEVE AND RETAINED ON THE NO. 4 SIEVE
- PL — PLASTIC LIMIT, PERCENT
- LL — LIQUID LIMIT, PERCENT
- PI — PLASTICITY INDEX (LL-PL), PERCENT
- MC — FIELD MOISTURE CONTENT, PERCENT OF DRY WEIGHT
- γ_d — FIELD DRY DENSITY, PCF
- G_s — SPECIFIC GRAVITY (MINUS NO. 4 SIEVE MATERIAL)
- OC — ORGANIC CONTENT, PERCENT
- PP — POCKET PENETROMETER
- TV — TORVANE
- UC — UNCONFINED COMPRESSION TEST
- UU — UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
- FV — FIELD VANE
- $q_{u/2}$ — ONE HALF OF THE UNCONFINED COMPRESSIVE STRENGTH, TSF
- S_u — UNDRAINED SHEAR STRENGTH, TSF
- ▽ — MEASURED GROUNDWATER LEVEL

NOTES:

1. BORINGS DRILLED WITH MOBILE B-53 DRILL RIG WITH 6.5-INCH DIAMETER HOLLOW STEM AUGER AND MOSS (MOBILE OPEN SPINDLE SYSTEM) SAMPLING WITH 3-INCH DIAMETER SAMPLE LINERS, CONTINUOUSLY SAMPLED. 7F-1-85 AND 7F-1A-85 DRILLED ON FEBRUARY 5, 1985. REMAINDER OF HOLES DRILLED ON MARCH 3 THROUGH 7, 1985.
2. SOIL CLASSIFICATIONS ARE IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487).
3. SAMPLES WHICH DO NOT HAVE MECHANICAL ANALYSIS OR ATTERBERG LIMITS INDICATED ON THE BORING LOGS WERE VISUALLY CLASSIFIED.
4. THE SOIL CLASSIFICATIONS AND DESCRIPTIONS PRESENTED ON THE LOGS ARE BASED ON LABORATORY MECHANICAL ANALYSES AND ATTERBERG LIMITS, LABORATORY VISUAL CLASSIFICATIONS, AND FIELD VISUAL CLASSIFICATIONS WITH MOST WEIGHT BEING GIVEN TO LABORATORY TESTS AND LABORATORY VISUAL CLASSIFICATIONS.
5. THE UNDRAINED SHEAR STRENGTH PRESENTED FOR THE UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST DATA IS BASED ON A $\phi = 0$ ASSUMPTION.
6. THE ESTIMATED IN SITU UNDISTURBED UNDRAINED SHEAR STRENGTH (80 PERCENT OF THE SHEAR STRENGTH MEASURED BY THE FIELD VANE TEST) IS PRESENTED ON THE LOGS FOR THE FIELD VANE DATA. (REFER TO THE LOGS OF FIELD VANE BORINGS).
7. ELEVATIONS REFER TO CORPS OF ENGINEERS DATUM.

REVISION	DATE	DESCRIPTION	BY

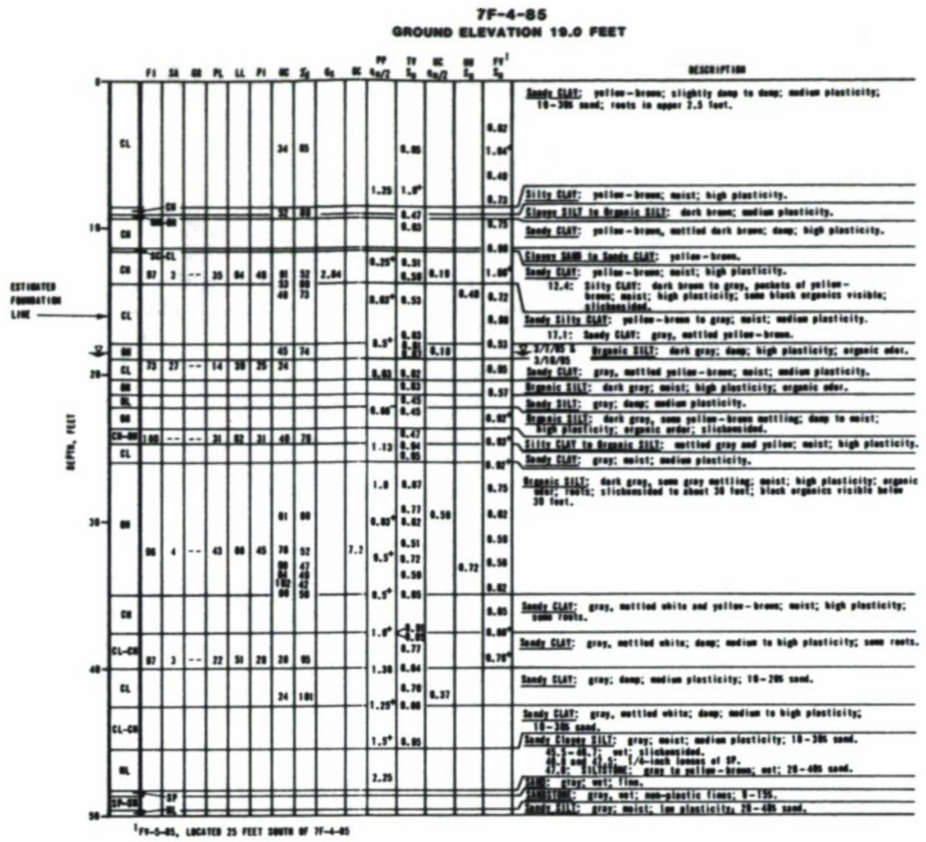
Wahler Associates

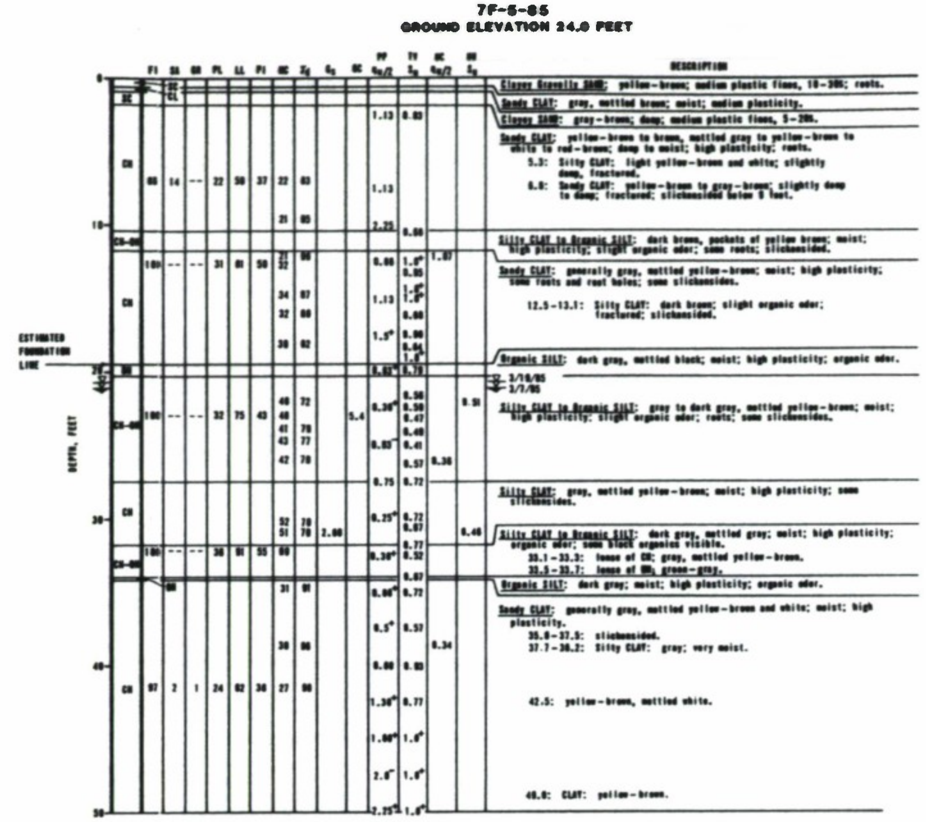
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

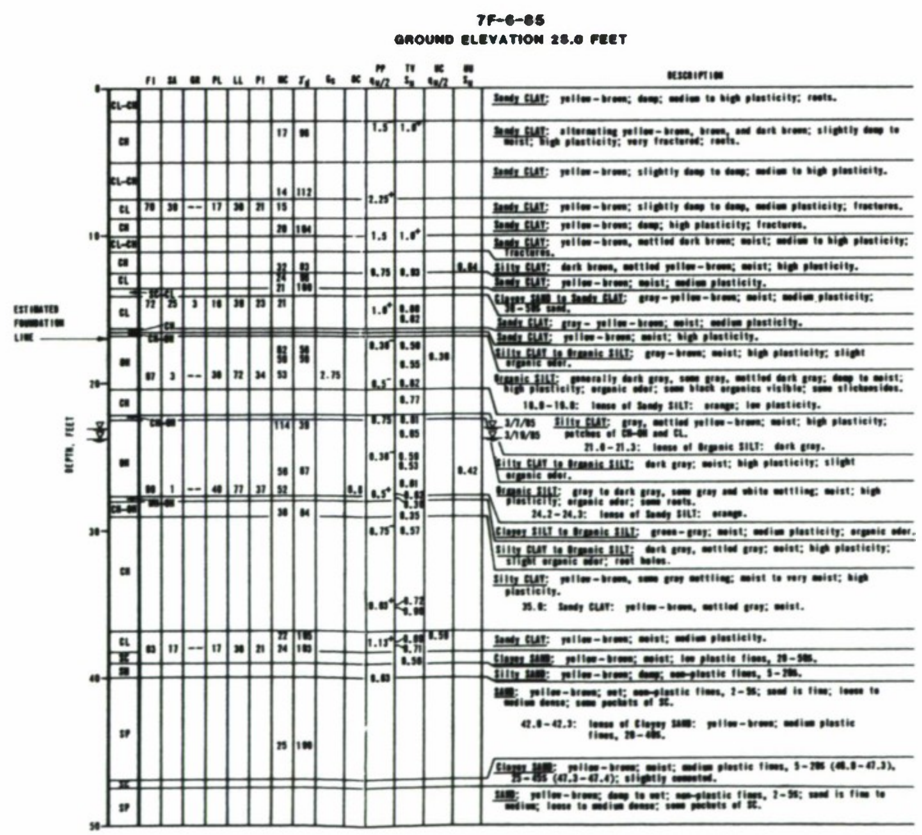
CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
EXISTING LEVEE INVESTIGATION
LOGS OF BORINGS

DESIGNED: S. R. KLINE
DRAWN: R. T. TARCZY
CHECKED: C. E. PERRY
SUBMITTED: [signature]
DATE APPROVED:
SCALE:
SPEC. No.
SHEET 5/21
FILE No. 50-10-5757

PLATE 6







UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487)

LEGEND

- FI FINES, PERCENT BY WEIGHT PASSING THE NO. 200 SIEVE
- SA SAND, PERCENT BY WEIGHT PASSING THE NO. 4 SIEVE AND RETAINED ON THE NO. 200 SIEVE
- GR GRAVEL, PERCENT BY WEIGHT PASSING THE 3-INCH SIEVE AND RETAINED ON THE NO. 4 SIEVE
- PL PLASTIC LIMIT, PERCENT
- LL LIQUID LIMIT, PERCENT
- PI PLASTICITY INDEX (LL-PL), PERCENT
- MC FIELD MOISTURE CONTENT, PERCENT OF DRY WEIGHT
- γ_d FIELD DRY DENSITY, PCF
- G_s SPECIFIC GRAVITY (MINUS NO. 4 SIEVE MATERIAL)
- OC ORGANIC CONTENT, PERCENT
- PP POCKET PENETROMETER
- TV TORVANE
- UC UNCONFINED COMPRESSION TEST
- UU UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
- FV FIELD VANE
- $q_u/2$ ONE HALF OF THE UNCONFINED COMPRESSIVE STRENGTH, TSF
- S_u UNDRAINED SHEAR STRENGTH, TSF
- ▽ MEASURED GROUNDWATER LEVEL

NOTES:

1. BORINGS DRILLED WITH MOBILE B-53 DRILL RIG WITH 6.5-INCH DIAMETER HOLLOW STEM AUGER AND RODS (MOBILE OPEN SPINDLE SYSTEM) SAMPLING WITH 3-INCH DIAMETER SAMPLE LINERS, CONTINUOUSLY SAMPLED. 7F-4-85 AND 7F-6-85 DRILLED ON FEBRUARY 5, 1985. REMAINDER OF HOLES DRILLED ON MARCH 6 THROUGH 7, 1985.
2. SOIL CLASSIFICATIONS ARE IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487).
3. SAMPLES WHICH DO NOT HAVE MECHANICAL ANALYSIS OR ATTERBERG LIMITS INDICATED ON THE BORING LOGS WERE VISUALLY CLASSIFIED.
4. THE SOIL CLASSIFICATIONS AND DESCRIPTIONS PRESENTED ON THE LOGS ARE BASED ON LABORATORY MECHANICAL ANALYSES AND ATTERBERG LIMITS, LABORATORY VISUAL CLASSIFICATIONS, AND FIELD VISUAL CLASSIFICATIONS WITH MOST WEIGHT BEING GIVEN TO LABORATORY TESTS AND LABORATORY VISUAL CLASSIFICATIONS.
5. THE UNDRAINED SHEAR STRENGTH PRESENTED FOR THE UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST DATA IS BASED ON A $\phi = 0$ ASSUMPTION.
6. THE ESTIMATED IN SITU UNDISTURBED UNDRAINED SHEAR STRENGTH (80 PERCENT OF THE SHEAR STRENGTH MEASURED BY THE FIELD VANE TEST) IS PRESENTED ON THE LOGS FOR THE FIELD VANE DATA. (REFER TO THE LOGS OF FIELD VANE BORINGS).
7. ELEVATIONS REFER TO CORPS OF ENGINEERS DATUM.

REVISION	DATE	DESCRIPTION	BY

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

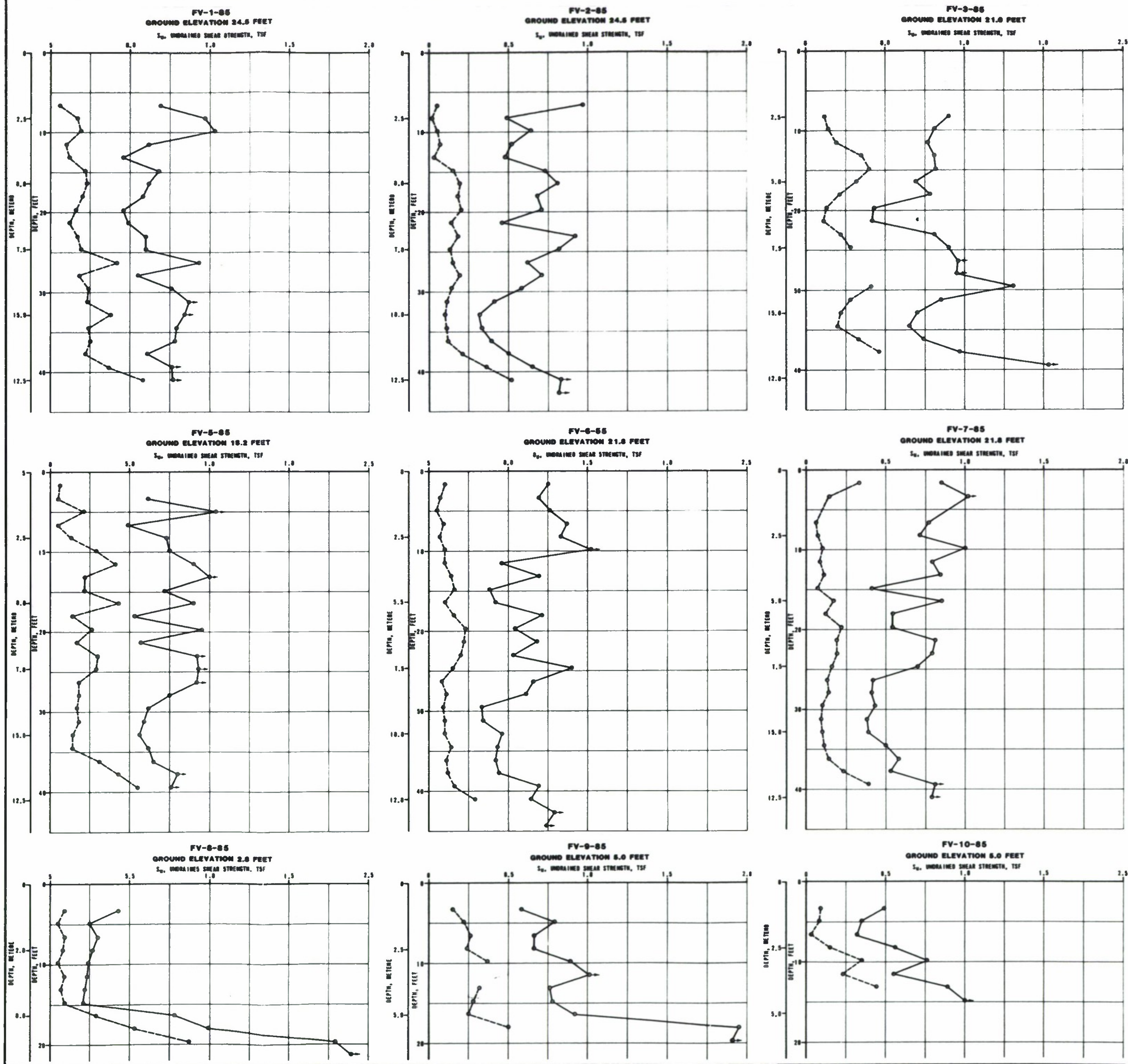
DESIGNED: D. R. KLINE
DRAWN: R. T. TARCZY
CHECKED: C. D. PEERY
SUBMITTED: [signature]

CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
EXISTING LEVEE INVESTIGATION
LOGS OF BORINGS

SHEET 6/21 FILE No. 50-10-5757

PLATE 6

FUNCTIONAL ANALYSIS - VE PAYS



LEGEND

- UNDISTURBED
- REMOLDED
- STRENGTH IS GREATER

NOTES:

1. FIELD VANE BORING AND TESTING DONE WITH [illegible] MODEL [illegible] VANE BORER WITH 11-CENTIMETER LONG BY 5-CENTIMETER DIAMETER AND 15-CENTIMETER LONG BY 6.5-CENTIMETER DIAMETER VANES. FV-1-85 THROUGH FV-7-85 DONE ON FEBRUARY 4 THROUGH 8 AND FEBRUARY 11 THROUGH 15, 1985. FV-8-85 THROUGH FV-10-85 DONE ON MARCH 19 AND 20, 1985.
2. ALL FIELD VANE BORINGS WERE ADVANCED TO A DEPTH AT WHICH REFUSAL TO FURTHER PENETRATION WAS REACHED.
3. UNDISTURBED AND REMOLDED VANE SHEAR TESTS WERE PERFORMED AT 0.5-METER INTERVALS. REMOLDED TESTS AT EACH DEPTH WERE PERFORMED IMMEDIATELY AFTER EACH UNDISTURBED TEST IN THE FIELD.
4. ALL FIELD VANE SHEAR TEST DATA IS CORRECTED FOR LOADING RATE EFFECT USING A CORRECTION FACTOR OF 0.8. THE LOGS OF FIELD VANE BORINGS PRESENTED ON THIS DRAWING INDICATE THE ESTIMATED IN SITU UNDISTURBED AND REMOLDED UNDRAINED SHEAR STRENGTH (80 PERCENT OF THE SHEAR STRENGTH MEASURED BY THE FIELD VANE TEST).
5. ELEVATIONS REFER TO CORPS OF ENGINEERS DATUM.

REVISION	DATE	DESCRIPTION	BY	BY

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: D. W. KLINE
DRAWN: W. T. TARCZY
CHECKED: C. W. PERRY

CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
EXISTING LEVEES INVESTIGATION

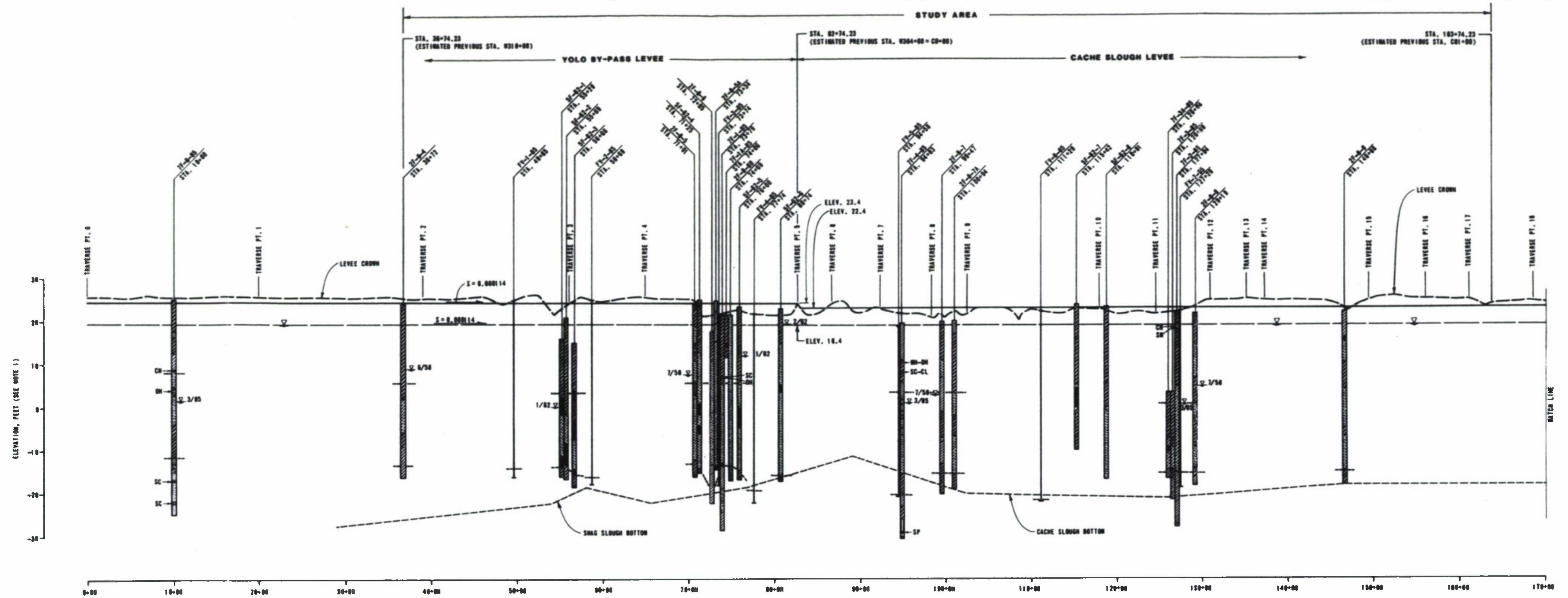
LOGS OF FIELD VANE BORINGS

SUBMITTED: Kenneth Pohl
DATE APPROVED:
SCALE:
SPEC. No.
SHEET 7/21
FILE No. 50-10-5757

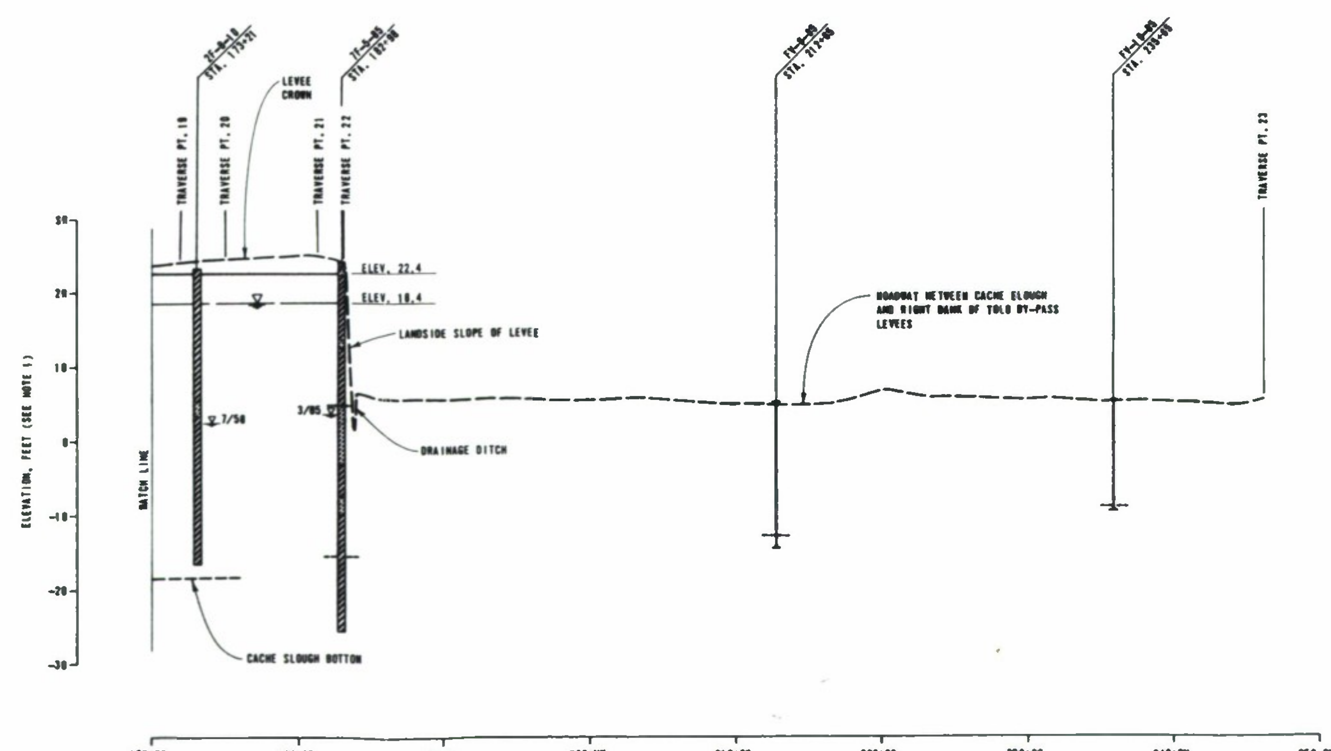
ENVIRONMENTAL ENGINEERING TECH ENGINEERING

SAFETY PAYS

PLATE 7



STATIONING ALONG LEVEE AND FOUNDATION PROFILE
HORIZONTAL SCALE: 1" = 500'   VERTICAL SCALE: 1" = 10'



STATIONING ALONG LEVEE AND FOUNDATION PROFILE
HORIZONTAL SCALE: 1" = 500'   VERTICAL SCALE: 1" = 10'

LEGEND

- LEVEE CROWN, JANUARY 1985 (SEE NOTE 2)
- STATE RECLAMATION BOARD ACCEPTED GRADE
- DESIGN FLOOD PLANE
- SLOUGH BOTTOM (SEE NOTE 3)
- MEASURED GROUNDWATER LEVEL
- ESTIMATED LEVEE FOUNDATION LINE
- ESTIMATED SURFACE OF STIFFER FOUNDATION
- CH, CLAY, HIGH PLASTICITY, MAY INCLUDE CL-CH CLASSIFICATIONS
- OH, ORGANIC SILT, HIGH PLASTICITY, MAY INCLUDE CH-OH AND MH-OH CLASSIFICATIONS
- MH, SILT, HIGH PLASTICITY
- CL, CLAY, GENERALLY MEDIUM PLASTICITY, MAY INCLUDE SC-CL CLASSIFICATIONS
- ML, SILT, LOW TO MEDIUM PLASTICITY
- SC, CLAYEY SAND
- SM, SILTY SAND, MAY INCLUDE SP-SM CLASSIFICATIONS
- SP, SAND

NOTES:

1. ELEVATIONS REFER TO CORPS OF ENGINEERS DATUM WHICH IS 3 FEET BELOW NATIONAL GEODETIC VERTICAL DATUM OF 1929 AT THIS SITE.
2. THE LEVEE CROWN IS A PROJECTION OF THE MAXIMUM LEVEE GRADE FROM TOPOGRAPHIC MAPS ONTO THE TRAVERSE LINE.
3. THE ESTIMATED SLOUGH BOTTOM IS BASED ON THE MAXIMUM DEPTH DETERMINED FROM SOUNDINGS TAKEN AT 10 SECTIONS ALONG SNAG SLOUGH AND CACHE SLOUGH.
4. STATIONS INDICATED FOR THE BORINGS ARE APPROXIMATE AND ARE SCALED FROM THEIR PROJECTED LOCATIONS ON THE TRAVERSE LINE. SEE SHEET 2 FOR A PLAN VIEW OF THE BORING LOCATIONS.
5. NO DATA WAS AVAILABLE FOR THE LOCATIONS OF BORINGS 2F-8-6A, 2F-8-6B, AND 2F-8-7A; THE LOCATION OF THESE HOLES IS ESTIMATED FROM A PREVIOUSLY DEVELOPED PROFILE INDICATING LOGS OF BORINGS FROM THE 1958 AND 1982 INVESTIGATIONS.

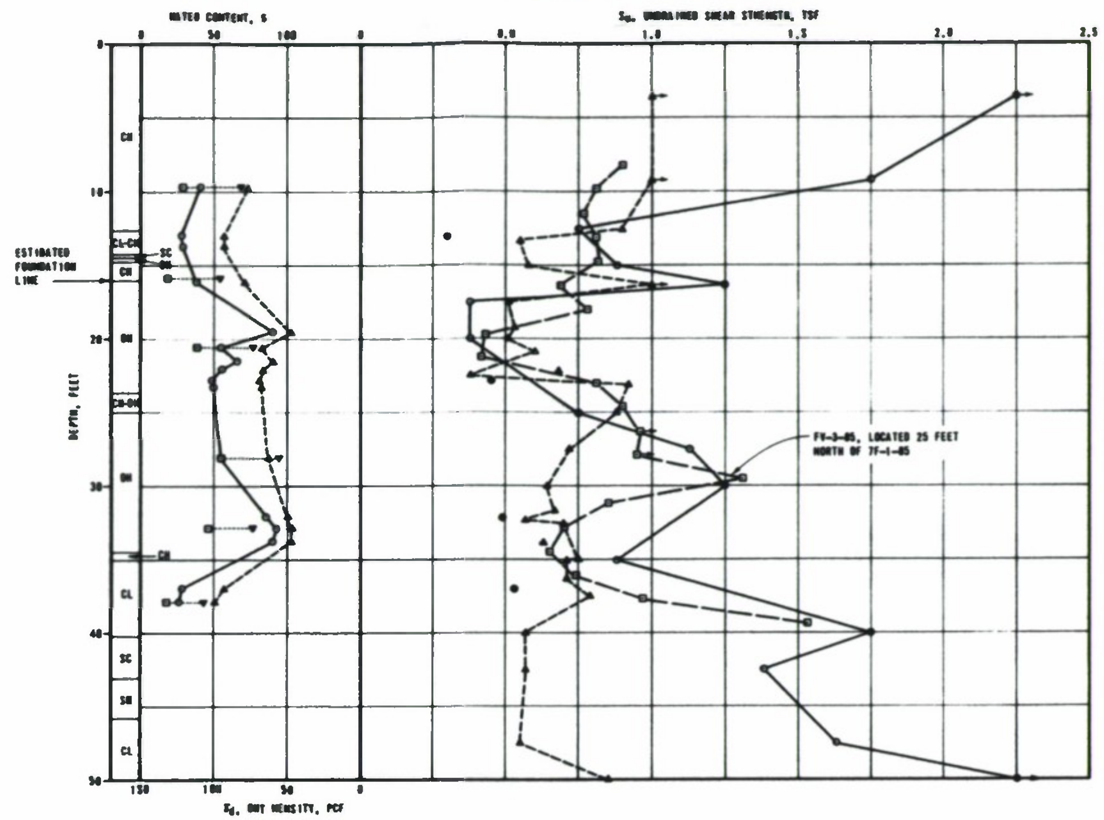
SCALES

500 0 500 FEET   10 0 10 FEET

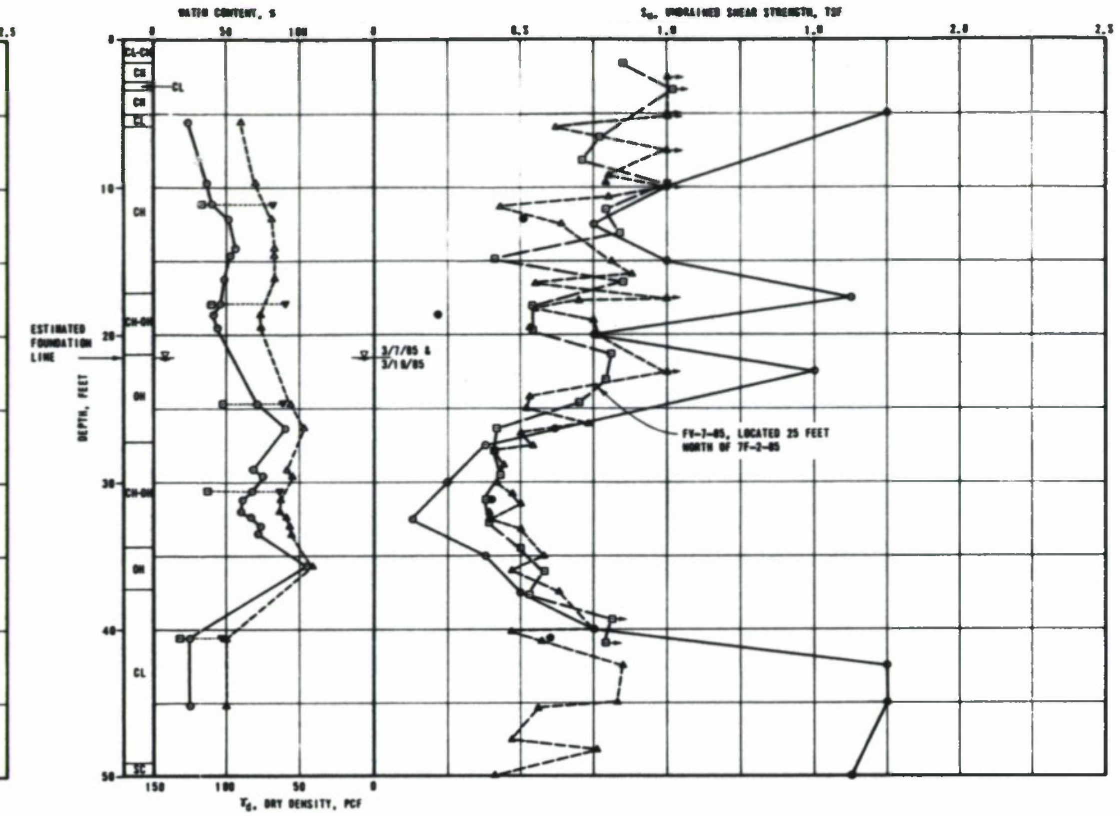
Wahler Associates	DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT, CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
DESIGNED: S. G. KLINE; DRAWN: G. T. TARCZY; CHECKED: C. U. PERRY	CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES EXISTING LEVEES INVESTIGATION LEVEE AND FOUNDATION PROFILE
SUBMITTED:	SHEET 8/21 FILE No. 50-10-5757

FUNCTIONAL ANALYSIS - VE PAYS

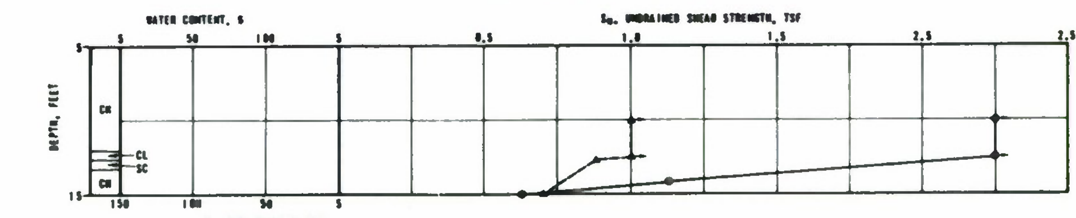
7F-1-85
GROUND ELEVATION 21.0 FEET



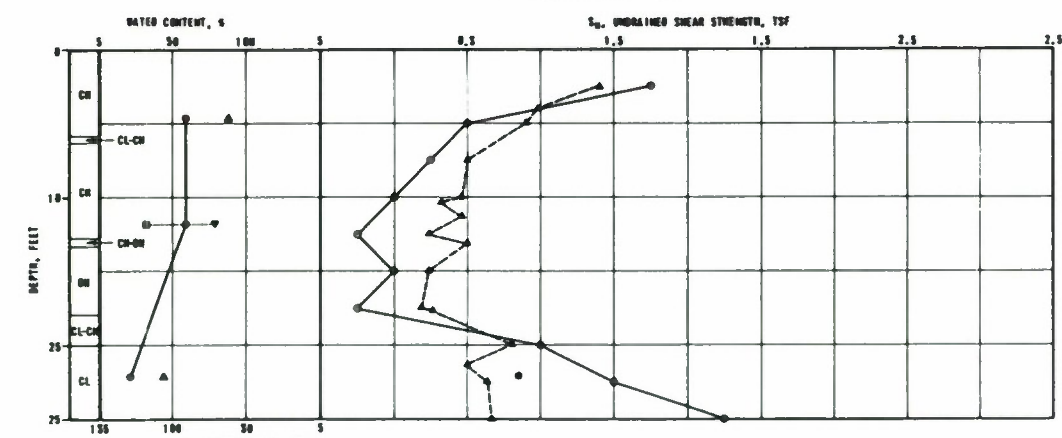
7F-2-85
GROUND ELEVATION 21.7 FEET



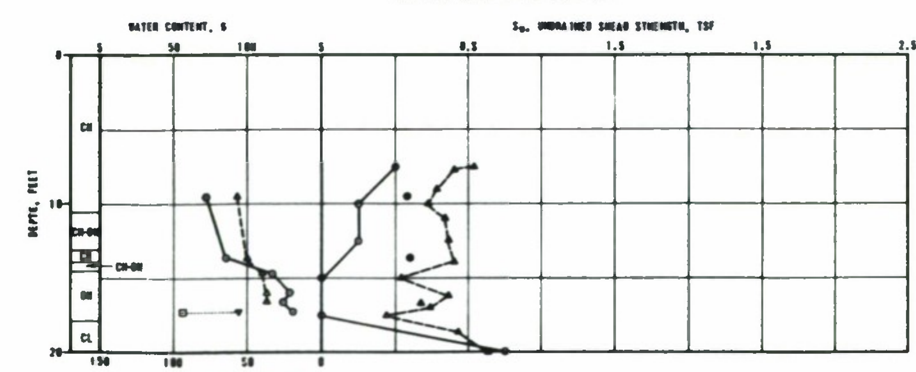
7F-1A-85
GROUND ELEVATION 21.0 FEET



7F-3-85
GROUND ELEVATION 3.0 FEET



7F-3A-85
GROUND ELEVATION 3.0 FEET



LEGEND

- MEASURED GROUNDWATER LEVEL

WATER CONTENT / DRY DENSITY

- WATER CONTENT
- DRY DENSITY
- PLASTIC LIMIT
- LIQUID LIMIT

UNDRAINED SHEAR STRENGTH

- POCKET PENETROMETER (SEE NOTE 2)
- TORVANE
- FIELD VANE (CORRECTED - SEE NOTE 3)
- UNCONFINED COMPRESSION TEST (SEE NOTE 4)
- UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (SEE NOTE 5)
- STRENGTH IS GREATER

NOTES:

1. SOIL CLASSIFICATIONS ARE IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487) AND ARE AS SHOWN ON THE LOGS OF BORINGS.
2. ONE HALF OF THE UNCONFINED COMPRESSIVE STRENGTH MEASURED BY THE POCKET PENETROMETER IS PRESENTED ON THE UNDRAINED SHEAR STRENGTH PLOT FOR THE POCKET PENETROMETER DATA.
3. THE ESTIMATED IN SITU UNDISTURBED UNDRAINED SHEAR STRENGTH (ON PERCENT OF THE SHEAR STRENGTH MEASURED BY THE FIELD VANE TEST) IS PRESENTED ON THE UNDRAINED SHEAR STRENGTH PLOT FOR THE FIELD VANE DATA. (REFER TO THE LOGS OF FIELD VANE BORINGS.)
4. ONE HALF OF THE UNCONFINED COMPRESSIVE STRENGTH IS PRESENTED ON THE UNDRAINED SHEAR STRENGTH PLOT FOR THE UNCONFINED COMPRESSION TEST DATA.
5. THE UNDRAINED SHEAR STRENGTH PRESENTED FOR THE UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST DATA IS BASED ON A $\phi = 0$ ASSUMPTION.
5. ELEVATIONS REFER TO CORPS OF ENGINEERS DATUM.

REVISION	DATE	DESCRIPTION	BY	BY

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: S. H. KLINE
DRAWN: R. T. TARCZY
CHECKED: C. R. PERRY
SUBMITTED:

CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
EXISTING LEVEES INVESTIGATION

SUMMARY OF LABORATORY TEST RESULTS

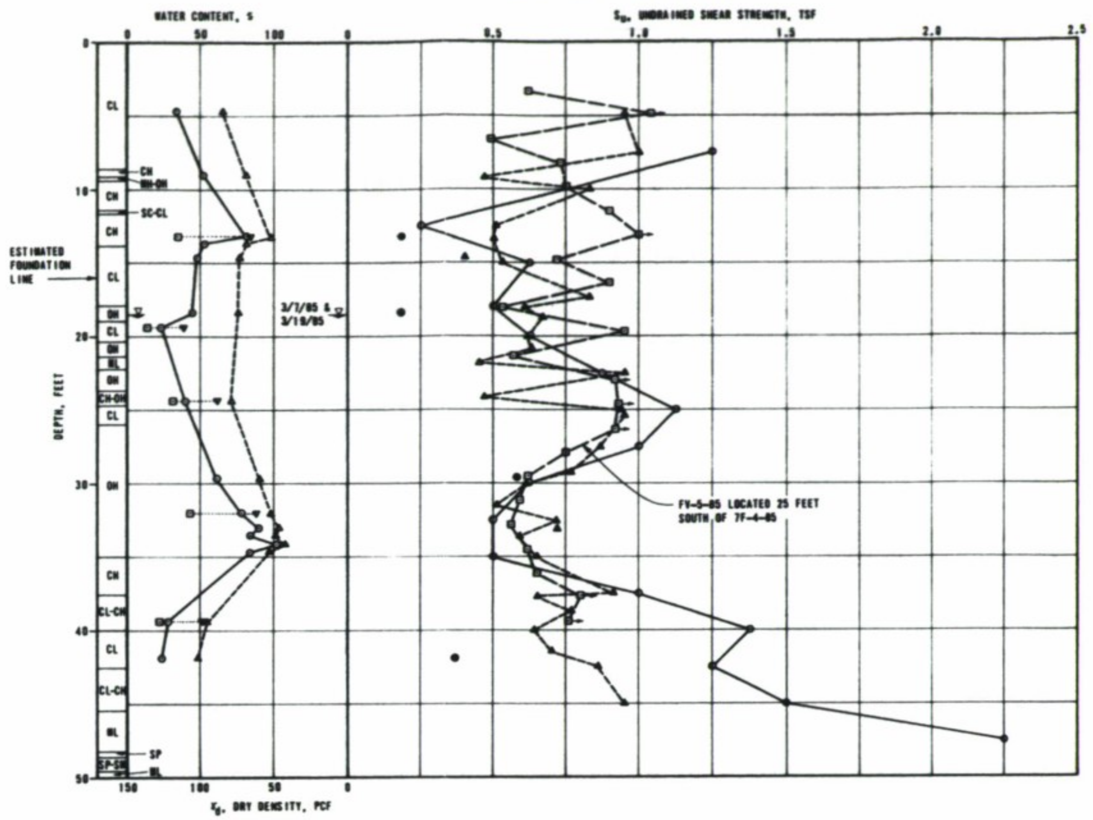
DATE APPROVED:
SCALE:
SHEET 9/21
FILE No. 50-10-5757
SPEC. No.

PLATE 9

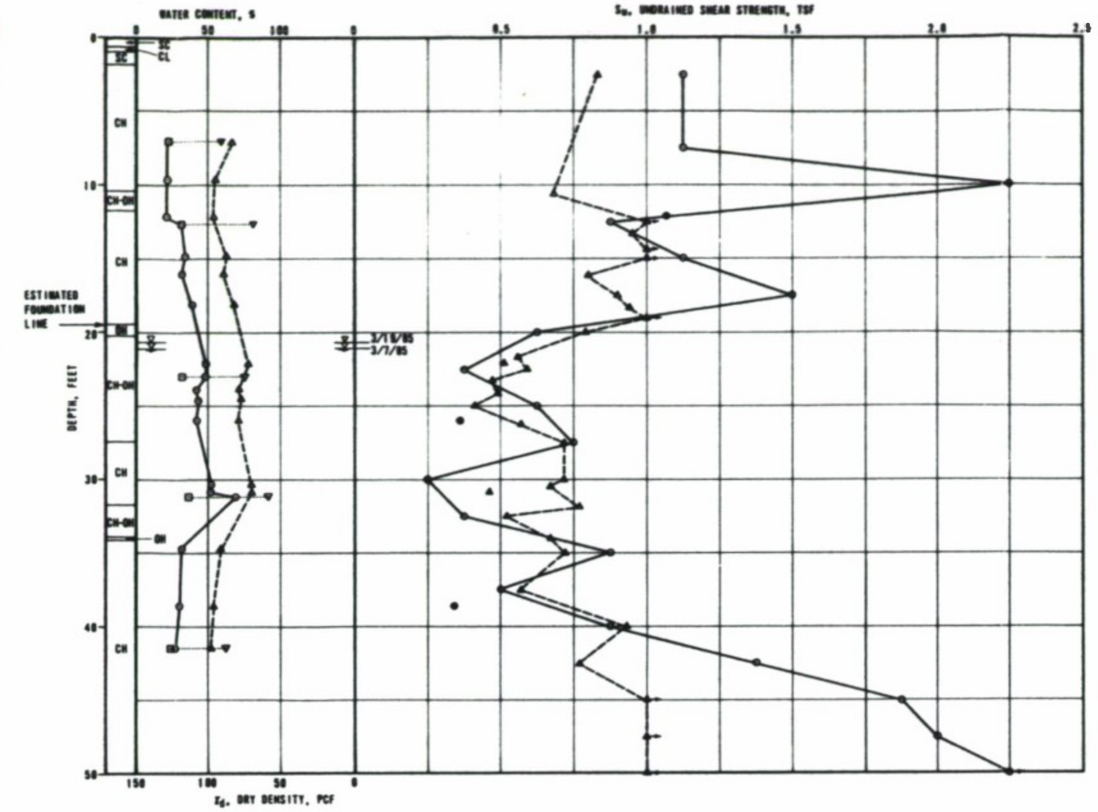
SAFETY PAYS

ENVIRONMENTAL ENGINEERING URBAN ENGINEERING

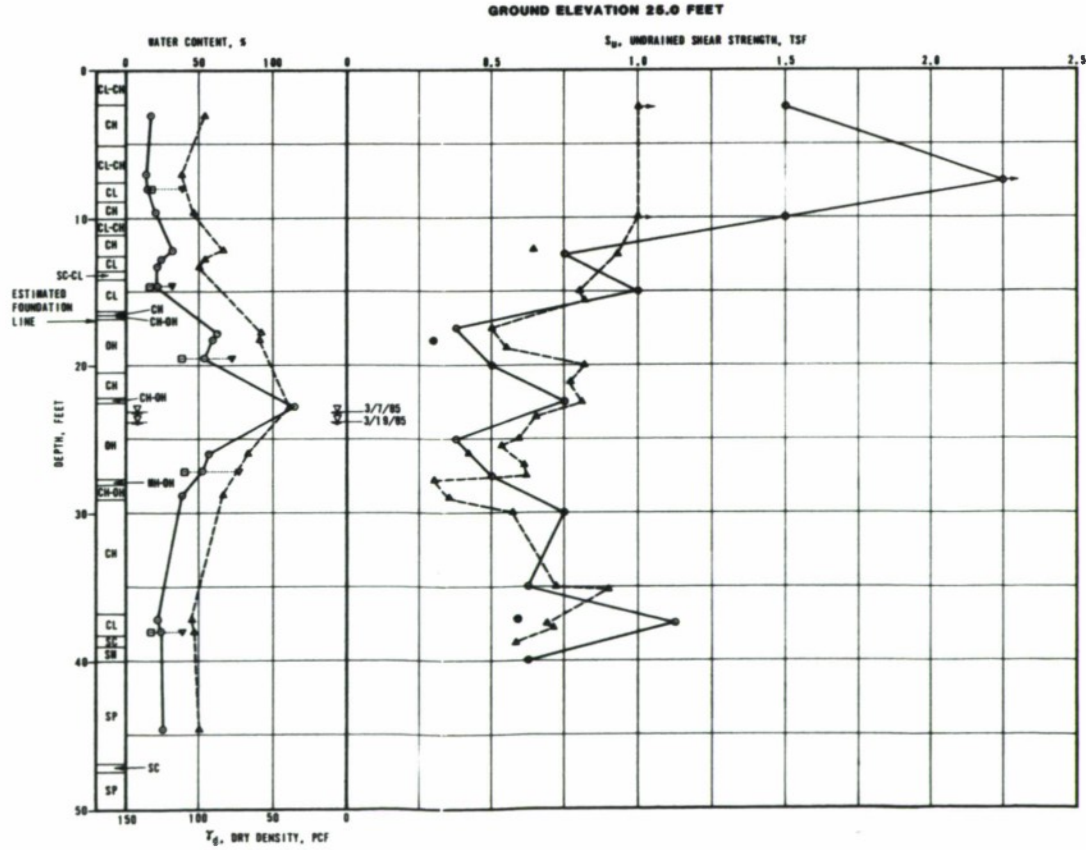
7F-4-85
GROUND ELEVATION 19.0 FEET



7F-5-85
GROUND ELEVATION 24.0 FEET



7F-6-85
GROUND ELEVATION 25.0 FEET



LEGEND

MEASURED GROUNDWATER LEVEL

WATER CONTENT / DRY DENSITY

- WATER CONTENT
- DRY DENSITY
- PLASTIC LIMIT
- LIQUID LIMIT

UNDRAINED SHEAR STRENGTHS

- POCKET PENETROMETER (SEE NOTE 2)
- TORVANE
- FIELD VANE (CORRECTED - SEE NOTE 3)
- UNCONFINED COMPRESSION TEST (SEE NOTE 4)
- UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (SEE NOTE 5)
- STRENGTH IS GREATER

NOTES:

1. SOIL CLASSIFICATIONS ARE IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487) AND ARE AS SHOWN ON THE LOGS OF BORINGS.
2. ONE HALF OF THE UNCONFINED COMPRESSIVE STRENGTH MEASURED BY THE POCKET PENETROMETER IS PRESENTED ON THE UNDRAINED SHEAR STRENGTH PLOT FOR THE POCKET PENETROMETER DATA.
3. THE ESTIMATED IN SITU UNDISTURBED UNDRAINED SHEAR STRENGTH (80 PERCENT OF THE SHEAR STRENGTH MEASURED BY THE FIELD VANE TEST) IS PRESENTED ON THE UNDRAINED SHEAR STRENGTH PLOT FOR THE FIELD VANE DATA. (REFER TO THE LOGS OF FIELD VANE BORINGS.)
4. ONE HALF OF THE UNCONFINED COMPRESSIVE STRENGTH IS PRESENTED ON THE UNDRAINED SHEAR STRENGTH PLOT FOR THE UNCONFINED COMPRESSION TEST DATA.
5. THE UNDRAINED SHEAR STRENGTH PRESENTED FOR THE UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST DATA IS BASED ON A $\phi = 0$ ASSUMPTION.
6. ELEVATIONS REFER TO CORPS OF ENGINEERS DATUM.

REVISION	DATE	DESCRIPTION	BY	BY

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

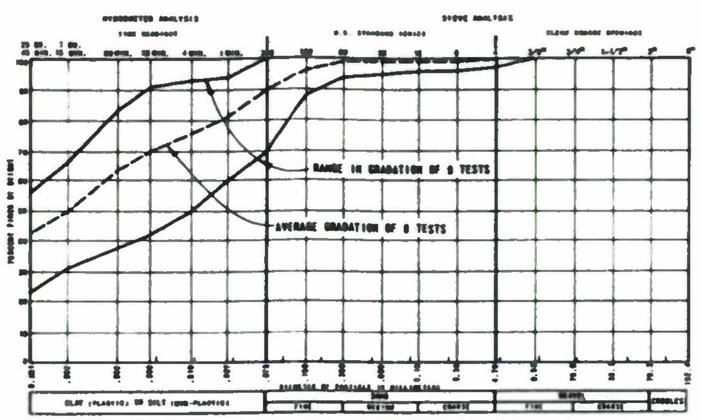
DESIGNED: S. S. KLINE
DRAWN: S. T. TARCZY
CHECKED: C. S. PERRY
SUBMITTED:

CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
EXISTING LEVEES INVESTIGATION
SUMMARY OF LABORATORY TEST RESULTS

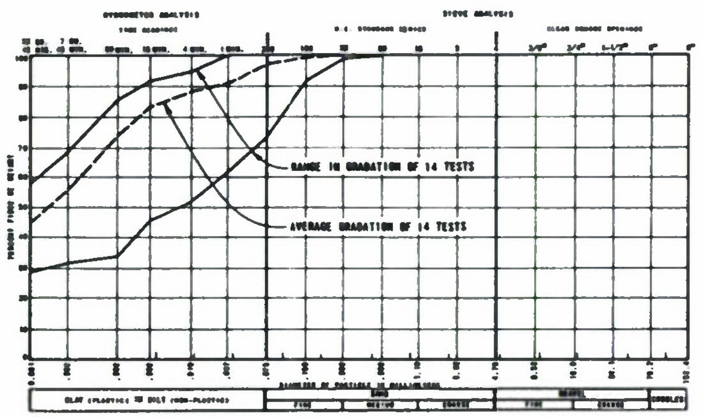
DATE APPROVED:
SCALE:
SPEC. No.
SHEET 10/21
FILE No. 50-10-5757

PLATE 10

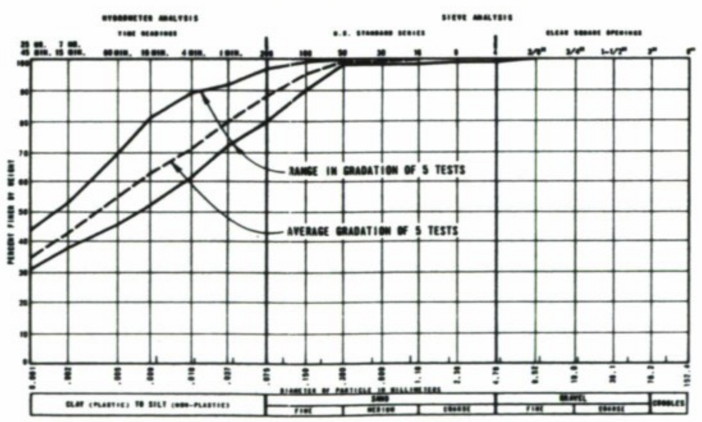
FUNCTIONAL ANALYSIS - VE PAYS



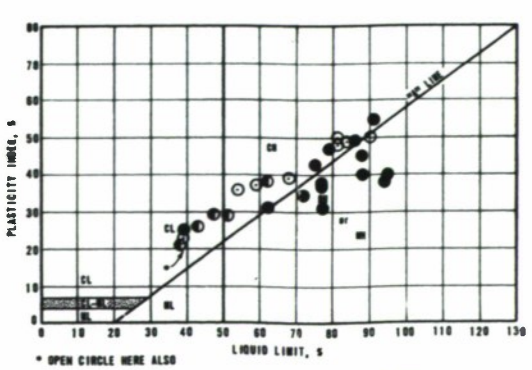
GRADATION - EXISTING LEVEE FILL
(MATERIAL ①- SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)



GRADATION - SOFTER FOUNDATION
(MATERIALS 2A AND 2B - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)



GRADATION - STIFFER FOUNDATION
(MATERIAL ③- SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)



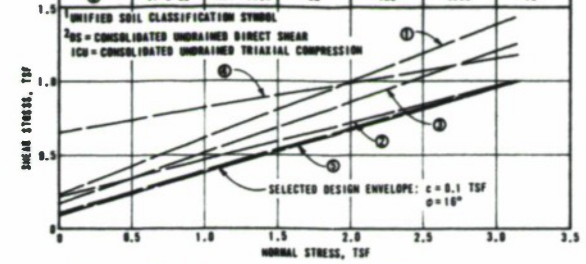
SYMBOL	MATERIAL[1]
○	①
●	2A & 2B
◐	③

[1] SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION

ATTERBERG LIMITS - PLASTICITY

ENVELOPE	HOLE	DEPTH (FT)	SOIL[1] TYPE	TEST[2]	c (TSF)	φ
①	7F-1-85	13.5-13.8	CL-CH	DS	0.23	21°
②	7F-2-85	13.8-14.8	CH	ICU	0.22	14°
③	7F-4-85	13.5-13.8	CH	DS	0.17	18°
④	7F-5-85	14.7-16.8	CH	DS	0.65	9.5°
⑤	7F-6-85	12.5-13.5	CL	ICU	0.08	18°

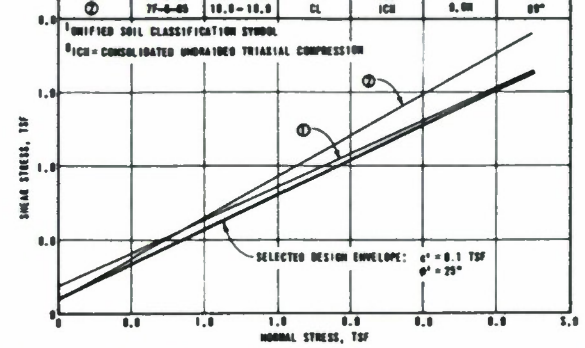
[1] UNIFIED SOIL CLASSIFICATION SYMBOL
[2] DS = CONSOLIDATED UNDRAINED DIRECT SHEAR
ICU = CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION



SHEAR STRENGTH - EXISTING LEVEE FILL - TOTAL STESS ENVELOPES
(MATERIAL ①- SEE SCHEMATIC OF EXISTING LEVEE AMD FOUNDATION)

ENVELOPE	HOLE	DEPTH (FT)	SOIL[1] TYPE	TEST[2]	c' (TSF)	φ'
①	7F-6-85	13.0-14.0	CH	ICU	0.10	24°
②	7F-6-85	18.0-18.0	CL	ICU	0.08	09°

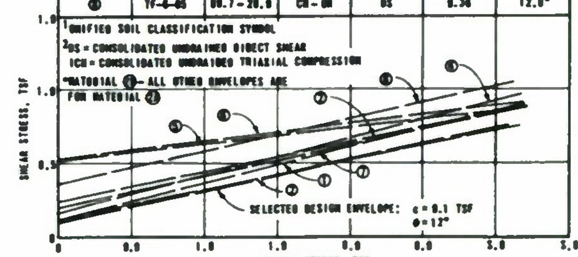
[1] UNIFIED SOIL CLASSIFICATION SYMBOL
[2] ICU = CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION



SHEAR STRENGTH - EXISTING LEVEE FILL - EFFECTIVE STRESS ENVELOPES
(MATERIAL ①- SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)

ENVELOPE	HOLE	DEPTH (FT)	SOIL[1] TYPE	TEST[2]	c (TSF)	φ
①	7F-1-85	18.0-21.7	OH	ICU	0.12	14°
②	7F-2-85	28.0-28.0	CH-OH	ICU	0.10	11.0°
③	7F-2-85	32.0-33.1	CH-OH	DS	0.24	11.0°
④*	7F-3A-85	14.0-14.0	OH	DS	0.17	14°
⑤	7F-4-85	33.5-00.0	OH	DS	0.52	8.0°
⑥	7F-4-85	33.0-34.0	OH	ICU	0.33	7°
⑦	7F-6-85	23.0-24.0	CH-OH	ICU	0.20	17°
⑧	7F-6-85	08.7-20.0	CH-OH	DS	0.36	12.0°

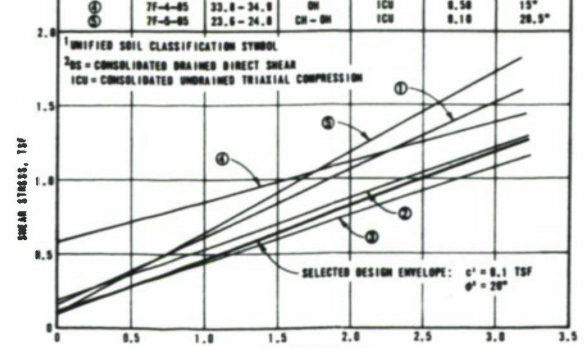
[1] UNIFIED SOIL CLASSIFICATION SYMBOL
[2] DS = CONSOLIDATED UNDRAINED DIRECT SHEAR
ICU = CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
*MATERIAL 2B - ALL OTHER ENVELOPES ARE FOR MATERIAL 2A



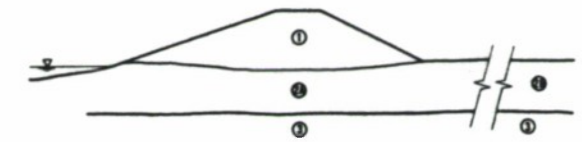
SHEAR STRENGTH - EXISTING LEVEE FOUNDATION -
TOTAL STESS ENVELOPES
(MATERIALS 2A AND 2B - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)

ENVELOPE	HOLE	DEPTH (FT)	SOIL[1] TYPE	TEST[2]	c' (TSF)	φ'
①	7F-1-85	19.2-21.7	OH	ICU	0.16	24.5°
②	7F-2-85	28.0-28.0	CH-OH	ICU	0.19	19°
③	7F-2-85	33.3-33.6	CH-OH	DS	0.12	18°
④	7F-4-85	33.0-34.9	OH	ICU	0.50	15°
⑤	7F-5-85	23.6-24.8	CH-OH	ICU	0.10	28.5°

[1] UNIFIED SOIL CLASSIFICATION SYMBOL
[2] DS = CONSOLIDATED DRAINED DIRECT SHEAR
ICU = CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION

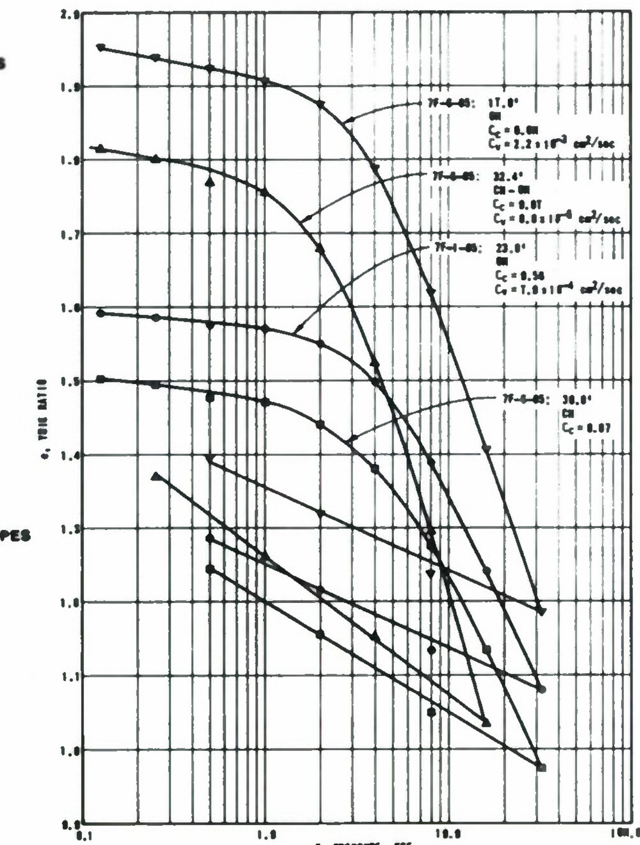


SHEAR STRENGTH - EXISTING LEVEE FOUNDATION -
EFFECTIVE STRESS ENVELOPES
(MATERIAL 2A - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)

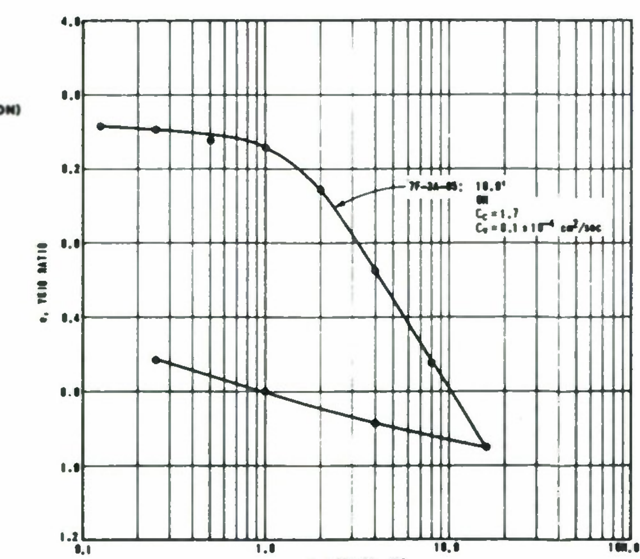


SCHEMATIC OF EXISTING LEVEE AND FOUNDATION
(NOT TO SCALE)

MATERIAL DESIGNATION	DESCRIPTION
①	FILL - EXISTING LEVEE
2A	SOFTER FOUNDATION - BENEATH EXISTING LEVEE
2B	SOFTER FOUNDATION - BEYOND TOE OF EXISTING LEVEE
③	STIFFER FOUNDATION



CONSOLIDATION - SOFTER FOUNDATION - BENEATH EXISTING LEVEE
(MATERIAL 2A - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)



CONSOLIDATION - SOFTER FOUNDATION -
BEYOND TOE OF EXISTING LEVEE
(MATERIAL 2B - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)

DESIGN PARAMETERS				
PARAMETER	SELECTED DESIGN VALUE			
	MATERIAL DESIGNATION			
	①	2A	2B	③
γ_m, MOIST DENSITY, PCF	110	90	90	120
S_u, IN SITU UNDRAINED SHEAR STRENGTH, TSF	0.4	0.0	0.2	SEE NOTE 2
c, COHESION[1], TSF	0.1	0.1	0.1	
φ, FRICTION ANGLE[1]	18°	12°	12°	
c', COHESION[2], TSF	0.1	0.1	0.1	
φ', FRICTION ANGLE[2]	25°	20°	20°	
C_c, COMPRESSION INDEX	ASSUME CONSOLIDATION NEGLIGIBLE	1.0	1.7	ASSUME CONSOLIDATION NEGLIGIBLE
C_v, COEFFICIENT OF CONSOLIDATION, cm²/sec		1.0 x 10^-4	8.0 x 10^-4	

[1] CONSOLIDATED UNDRAINED - TOTAL STRESS (R) ENVELOPE
[2] CONSOLIDATED UNDRAINED - EFFECTIVE STRESS ($\bar{R}$) ENVELOPE

NOTES:
1. THE COMPRESSION INDEX, C_c, INDICATED FOR EACH CONSOLIDATION TEST IS BASED ON THE CORRECTED FIELD VIRGIN COMPRESSION CURVE. THE CONSOLIDATION VOID RATIO VERSUS LOG OF PRESSURE CURVES SHOWN ON THIS DRAWING ARE THE LABORATORY CURVES.
2. BASED PRIMARILY ON THE RESULTS OF FIELD VANE TESTING, WHICH INDICATES A SIGNIFICANTLY GREATER STRENGTH IN THE STIFFER FOUNDATION, IT IS JUDGED THAT POTENTIAL FAILURE SURFACES WOULD REMAIN WITHIN THE SOFTER FOUNDATION AND WOULD NOT PASS THROUGH THE UNDERLYING STIFFER FOUNDATION. STABILITY ANALYSES WILL BE PERFORMED AND STRENGTH PARAMETERS FOR MATERIAL 3 WILL BE CHOSEN IN SUCH A WAY TO MODEL THIS EXPECTED BEHAVIOR OF POTENTIAL FAILURE SURFACES.

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

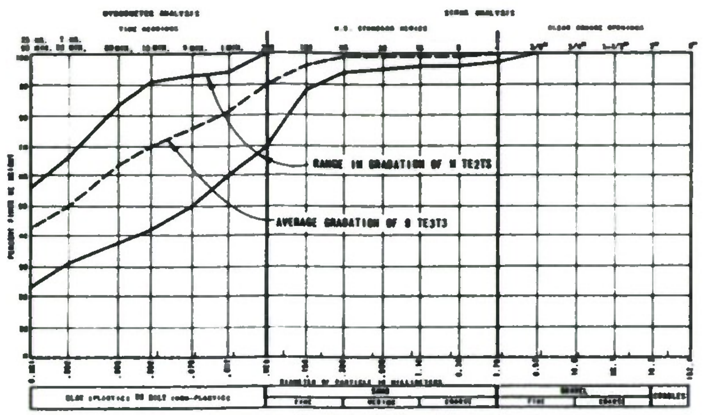
CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
EXISTING LEVEES INVESTIGATION
SUMMARY OF LABORATORY TEST RESULTS

DESIGNED: S. G. KLINE
DRAWN: R. T. TARCZY
CHECKED: C. R. PERRY
SUBMITTED: [signature]

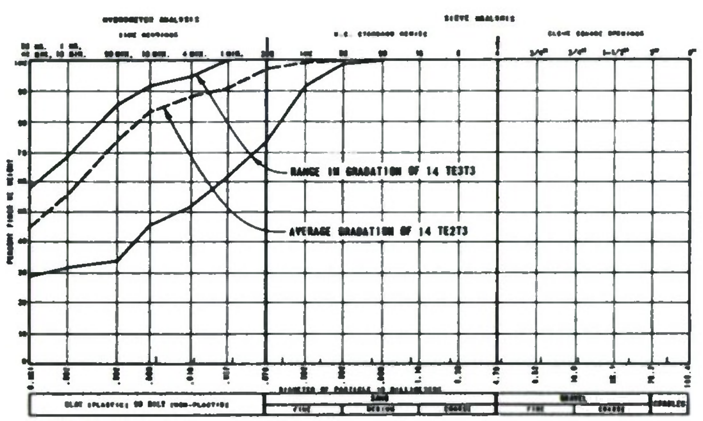
SHEET 11/21 FILE No. 50-10-5757

PLATE 11

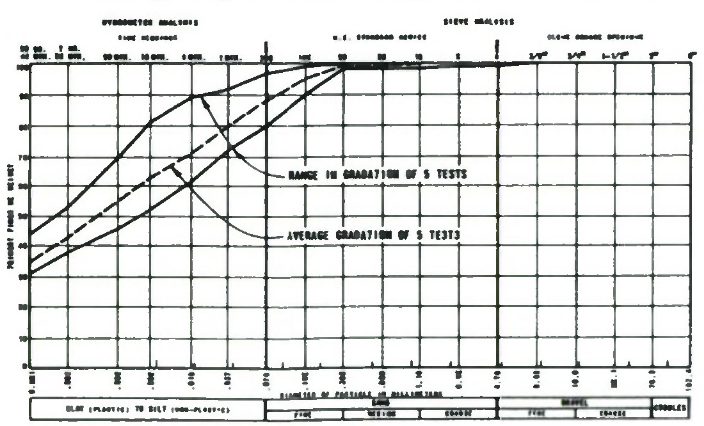
SAFETY PAYS



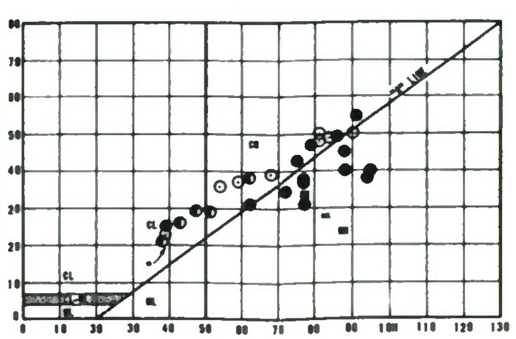
GRADATION - EXISTING LEVEE FILL
(MATERIAL ① - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)



GRADATION - SOFTER FOUNDATION
(MATERIALS 2A AND 2B - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)



GRADATION - STIFFER FOUNDATION
(MATERIAL ③ - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)



SYMBOL	MATERIAL[1]
○	①
●	2A & 2B
◐	③

[1] SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION

* OPEN CIRCLE HERE ALSO

ATTERBERG LIMITS - PLASTICITY

ENVELOPE	HOLE	DEPTH (FT)	SOIL[1] TYPE	TEST[2]	c (TSF)	ø
①	7F-1-85	13.5-13.0	CL-CH	DS	0.23	21°
②	7F-2-85	13.0-14.0	CH	ICU	0.22	14°
③	7F-4-85	13.5-13.0	CH	DS	0.17	16°
④	7F-5-85	14.7-16.0	CH	DS	0.65	8.5°
⑤	7F-6-85	12.5-13.5	CL	ICU	0.00	16°

[1] UNIFIED SOIL CLASSIFICATION SYMBOL
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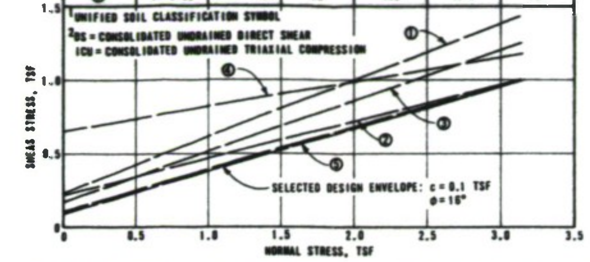
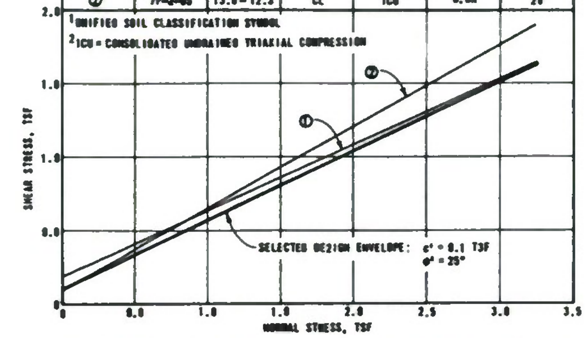
ICU = CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION



SHEAR STRENGTH - EXISTING LEVEE FILL - TOTAL STESS ENVELOPES
(MATERIAL ① - SEE SCHEMATIC OF EXISTING LEVEE AMD FOUNDATION)

ENVELOPE	HOLE	DEPTH (FT)	SOIL[1] TYPE	TEST[3]	c' (TSF)	ø'
①	7F-2-85	13.0-14.0	CH	ICU	0.10	24°
②	7F-2-85	13.0-12.5	CL	ICU	0.00	20°

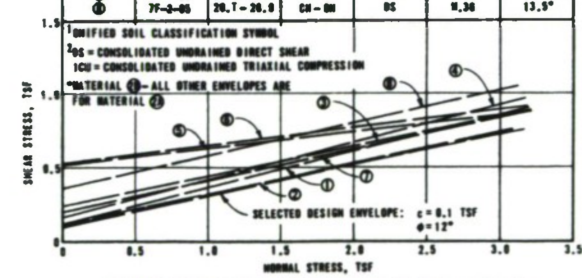
[1] UNIFIED SOIL CLASSIFICATION SYMBOL
[2] ICU = CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION



SHEAR STRENGTH - EXISTING LEVEE FILL - EFFECTIVE STRESS ENVELOPES
(MATERIAL ① - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)

ENVELOPE	HOLE	DEPTH (FT)	SOIL[1] TYPE	TEST[3]	c (TSF)	ø
①	7F-1-85	18.2-21.7	OH	ICU	0.12	14°
②	7F-2-85	20.0-20.0	CH-OH	ICU	0.13	11.5°
③	7F-2-85	33.0-33.1	CH-OH	DS	0.24	11.5°
④*	7F-3A-85	14.0-14.0	OH	DS	0.17	14°
⑤	7F-4-85	23.3-33.0	OH	DS	0.52	8.5°
⑥	7F-4-85	33.0-34.0	OH	ICU	0.53	7°
⑦	7F-6-85	25.0-24.0	CH-OH	ICU	0.20	12°
⑧	7F-2-85	20.7-20.0	CH-OH	DS	0.36	13.5°

[1] UNIFIED SOIL CLASSIFICATION SYMBOL
[2] DS = CONSOLIDATED UNDRAINED DIRECT SHEAR
ICU = CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION
*MATERIAL 2B - ALL OTHER ENVELOPES ARE FOR MATERIAL 2A



SHEAR STRENGTH - EXISTING LEVEE FOUNDATION -
TOTAL STESS ENVELOPES
(MATERIALS 2A AND 2B - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)

ENVELOPE	HOLE	DEPTH (FT)	SOIL[1] TYPE	TEST[2]	c' (TSF)	ø'
①	7F-1-85	19.2-21.7	OH	ICU	0.16	24.5°
②	7F-2-85	20.0-20.0	CH-OH	ICU	0.19	19°
③	7F-2-85	33.3-33.6	CH-OH	DS	0.12	18°
④	7F-4-85	33.0-34.0	OH	ICU	0.50	15°
⑤	7F-6-85	23.0-24.0	CH-OH	ICU	0.10	20.5°

[1] UNIFIED SOIL CLASSIFICATION SYMBOL
[2] DS = CONSOLIDATED DRAINED DIRECT SHEAR
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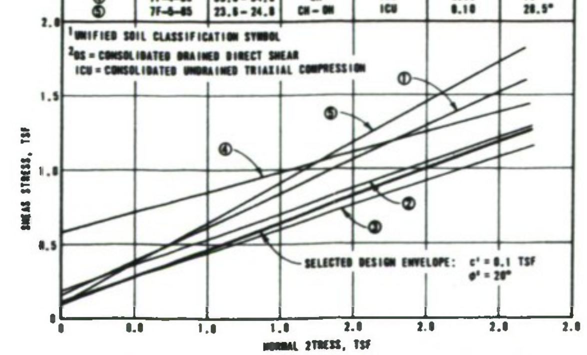
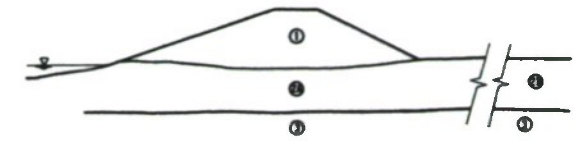
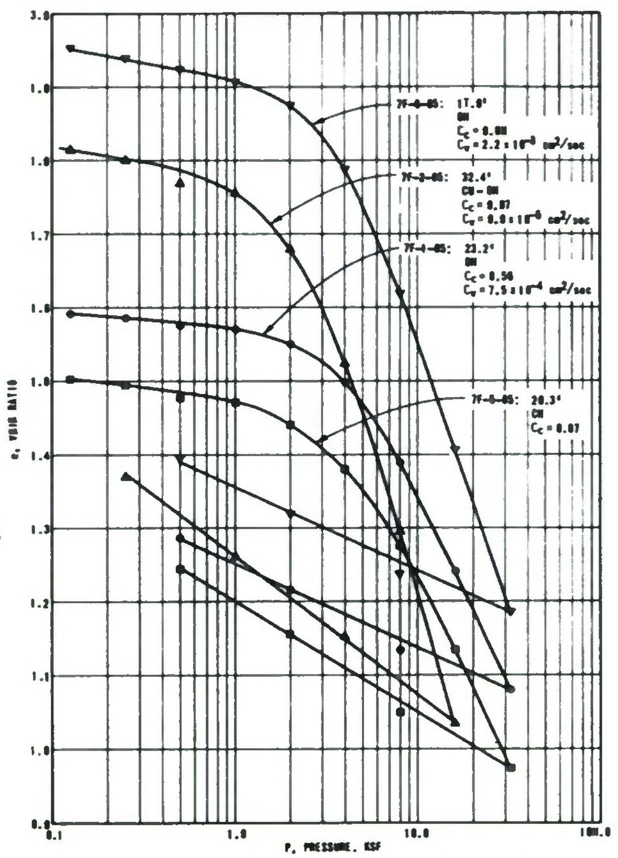


SHEAR STRENGTH - EXISTING LEVEE FOUNDATION -
EFFECTIVE STRESS ENVELOPES
(MATERIAL 2A - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)

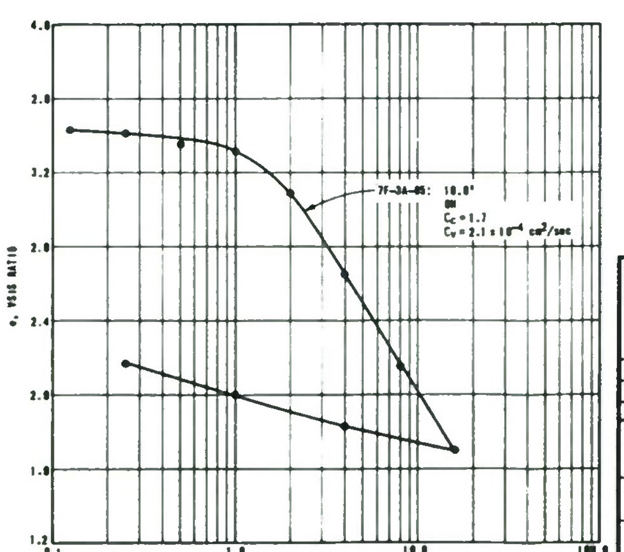


SCHEMATIC OF EXISTING LEVEE AND FOUNDATION
(NOT TO SCALE)

MATERIAL DESIGNATION	DESCRIPTION
①	FILL - EXISTING LEVEE
2A	SOFTER FOUNDATION - BENEATH EXISTING LEVEE
2B	SOFTER FOUNDATION - BEYOND THE OF EXISTING LEVEE
③	STIFFER FOUNDATION



CONSOLIDATION - SOFTER FOUNDATION - BENEATH EXISTING LEVEE
(MATERIAL 2A - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)



CONSOLIDATION - SOFTER FOUNDATION -
BEYOND TOE OF EXISTING LEVEE
(MATERIAL 2B - SEE SCHEMATIC OF EXISTING LEVEE AND FOUNDATION)

DESIGN PARAMETERS				
PARAMETER	SELECTED DESIGN VALUE — MATERIAL DESIGNATION			
	①	2A	2B	③
γ_m, MOIST DENSITY, PCF	110	95	90	125
S_u, IN SITU UNDRAINED SHEAR STRENGTH, TSF	0.4	0.3	0.3	SEE NOTE 3
c, COHESION[1], TSF	0.1	0.1	0.1	SEE NOTE 3
ø, FRICTION ANGLE[1]	16°	12°	12°	SEE NOTE 3
c', COHESION[2], TSF	0.1	0.1	0.1	SEE NOTE 3
ø', FRICTION ANGLE[2]	25°	30°	20°	SEE NOTE 3
C_c, COMPRESSION INDEX	ASSUME CONSOLIDATION NEGLIGIBLE	1.0	1.7	ASSUME CONSOLIDATION NEGLIGIBLE
C_v, COEFFICIENT OF CONSOLIDATION, cm^2/sec	ASSUME CONSOLIDATION NEGLIGIBLE	1.0 x 10^{-4}	3.0 x 10^{-4}	ASSUME CONSOLIDATION NEGLIGIBLE

[1] CONSOLIDATED UNDRAINED - TOTAL STRESS (R) ENVELOPE
[2] CONSOLIDATED UNDRAINED - EFFECTIVE STRESS ($\bar{R}$) ENVELOPE

NOTES:

1. THE COMPRESSION INDEX, C_c, INDICATED FOR EACH CONSOLIDATION TEST IS BASED ON THE CORRECTED FIELD VIRGIN COMPRESSION CURVE. THE CONSOLIDATION VOID RATIO VERSUS LOG OF PRESSURE CURVES SHOWN ON THIS DRAWING ARE THE LABORATORY CURVES.
2. BASED PRIMARILY ON THE RESULTS OF FIELD VANE TESTING, WHICH INDICATES A SIGNIFICANTLY GREATER STRENGTH IN THE STIFFER FOUNDATION, IT IS JUDGED THAT POTENTIAL FAILURE SURFACES WOULD REMAIN WITHIN THE SOFTER FOUNDATION AND WOULD NOT PASS THROUGH THE UNDERLYING STIFFER FOUNDATION. STABILITY ANALYSES WILL BE PERFORMED AND STRENGTH PARAMETERS FOR MATERIAL 3 WILL BE CHOSEN IN SUCH A WAY TO MODEL THIS EXPECTED LOCATION OF POTENTIAL FAILURE SURFACES.

REVISION	DATE	DESCRIPTION	BY	BY

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: S. H. KLINE
DRAWN: R. T. TARCZY
CHECKED: C. H. PERRY

CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
EXISTING LEVEES INVESTIGATION

SUMMARY OF LABORATORY TEST RESULTS

SUBMITTED: [signature]
DATE APPROVED:
SCALE:
SPEC. No.
SHEET 11/21
FILE No. 50-10-5757

PLATE 11

20-1-85

DEPTH, FEET	USCS	SAMPLE	FI	SA	GR	PL	LL	PI	MC	G_s
0–15.0	CL	1	75	25	--	17	36	19	25	--
		2	87	13	--	18	43	25	21	--
		3	--	--	--	--	--	--	30	--

DESCRIPTION

Sandy CLAY: gray-brown; fine sand.

6.0: yellow-brown.

Medium to high plasticity.

20-2-85

DEPTH, FEET	USCS	SAMPLE	FI	SA	GR	PL	LL	PI	MC	G_s
0–10.0	CL	1	80	10	--	20	40	20	18	2.80
		2	50	42	3	15	33	17	14	--
10.0–15.0	ML	3	86	11	--	--	--	--	34	--

DESCRIPTION

Sandy Silty CLAY: gray-brown; fine sand.

6.0: yellow-brown.

Sandy CLAY: fine to medium sand.

Clayey SILT: yellow-brown; medium plasticity; soft.

20-3-85

USCS	SAMPLE	FI	SA	GR	PL	LL	PI	MC	G_s	DESCRIPTION
CL	1	90	10	--	30	45	25	22	--	Sandy CLAY: gray-brown; fine sand.
CL-CH	2	--	--	--	--	--	--	10	--	Sandy CLAY: gray-brown; high plasticity; fine sand.
SC	2	--	--	--	--	--	--	--	--	Clayey SAND: brown some gray; moist; medium plastic fines, 15-20%; fine sand.
CL-CH										Sandy CLAY: gray-brown; high plasticity; fine sand.
CL	3	--	--	--	--	--	--	20	--	Sandy CLAY: brown, mottled gray; medium plasticity. ▽ 4/16/85
CH	4	91	9	--	34	88	54	36	--	Silty CLAY: gray; stiff; slight organic odor.

20-4-85

USCS	SAMPLE	FI	SA	GR	PL	LL	PI	MC	G_s	DESCRIPTION
CL-CH	1	80	15	--	21	50	29	29	--	Sandy CLAY to Silty CLAY: gray-brown; fine sand.
SC	2	54	[illegible]	--	--	--	--	13	--	Clayey SAND: yellow-brown; fine to medium sand.
CL	3	--	--	--	--	--	--	33	--	Sandy CLAY: yellow-brown; medium plasticity; very soft.
CH	4	--	--	--	--	--	--	--	--	Sandy CLAY: gray; moist; high plasticity; stiff; slight organic odor.

20-5-85

USCS	SAMPLE	FI	SA	GR	PL	LL	PI	MC	G_s	DESCRIPTION
SC	1	37	62	1	18	25	8	18	--	Clayey SAND: yellow-brown; fine to medium sand.
	2	30	[illegible]	--	--	--	--	14	2.70	Medium plastic fines.
CL	3	74	20	--	--	--	--	20	--	Sandy CLAY: yellow-brown; fine sand; soft.
CH	4	--	--	--	--	--	--	--	--	Sandy CLAY: gray; moist; high plasticity; slight organic odor.

20-6-85

USCS	SAMPLE	FI	SA	GR	PL	LL	PI	MC	G_s	DESCRIPTION
CL-CH	1	87	13	--	22	61	39	30	2.75	Silty CLAY: gray.
CL	3	70	20	5	--	--	--	25	--	Silty Sandy CLAY: yellow-brown; damp; medium plasticity. 7.0: wet; soft.
CH	5	92	8	--	--	--	--	33	--	Silty CLAY: gray; high plasticity. ▽ 4/16/85

20-7-85

USCS	SAMPLE	DESCRIPTION
SC	1	Clayey SAND: gray; moist; medium plastic fines.
CL	3	Sandy CLAY: yellow-brown; damp to moist; medium plasticity; fine sand. 8.0: moist to wet.
CH	3	Sandy CLAY: gray-brown; moist; high plasticity.

20-8-85

USCS	SAMPLE	DESCRIPTION
CH	1	Sandy CLAY: grey-brown; moist; high plasticity; slight organic odor.
GP		Silty Sandy GRAVEL: fine gravel, subrounded; fine to coarse sand.
CL		Silty CLAY: yellow-brown; medium plasticity; fine sand.
SC	2	Clayey Gravelly SAND: gray-brown; moist; low plastic fines; 5-15% gravel, subangular, 1" maximum size.
CL	3	Sandy CLAY: yellow-brown; wet; medium plasticity.
	4	Less sand. ▽ 4/16/85

20-9-85

USCS	SAMPLE	DESCRIPTION
CH	1	Sandy CLAY: gray-brown; moist; high plasticity.
CL-SC	3	Sandy CLAY to Clayey SAND: yellow-brown; moist; medium plasticity.
CH	3	CLAY: yellow brown and gray; moist; high plasticity.
		Silty CLAY: yellow-brown; moist; fine sand.

20-10-85

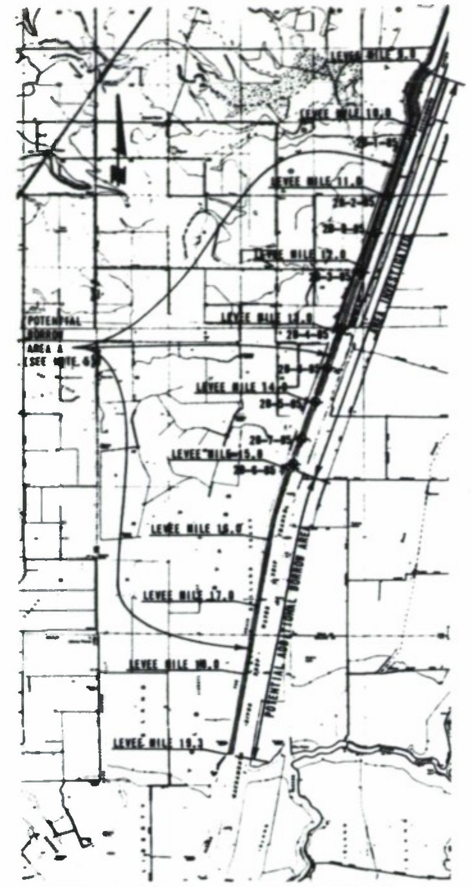
USCS	SAMPLE	FI	SA	GR	PL	LL	PI	MC	G_s	DESCRIPTION
CH-OH	1	--	--	--	30	61	05	55	--	Silty CLAY to Organic SILT: dark gray with some yellow-brown.
	4									3.0-4.0: lenses of clayey sand: red-brown; wet; soft.
CH	3	--	--	--	33	70	40	65	--	Silty CLAY: dark gray with some yellow-brown.
	3	--	--	--	21	81	50	00	--	▽ 4/18/85

20-11-85

DEPTH, FEET	USCS	SAMPLE	DESCRIPTION
0	CH-OH	1	Silty CLAY to Organic SILT: dark gray; moist; high plasticity; some black organics visible.
5.0	CH	3	Sandy CLAY: grey-brown; wet; high plasticity. 8.0-10.0: layers of clayey sand and silty clay; green-gray. ▽ 4/16/85
10.0	CH-OH	4	Silty CLAY to Organic SILT: dark gray; wet; high plasticity; slight organic odor.
15.0			Note: Below 10', material retrieved and logged only at depths indicated, and boundaries between different material types not shown.
20.0	CL	6	20.0: Silty CLAY: green-yellow; stiff.
25.0	CL	6	25.0: Sandy Silty CLAY: yellow-brown, stiff.
30.0	CL	7	30.0: Sandy Silty CLAY: yellow-brown; fine sand; very stiff.
35.0	ML	8	35.0: Sandy SILT: yellow-brown; fine sand.
40.0	SM	9	40.0: Silty SAND: yellow-brown; fine sand.
45.0			
50.0	CL	10	50.0: Silty CLAY: yellow-brown, stiff.

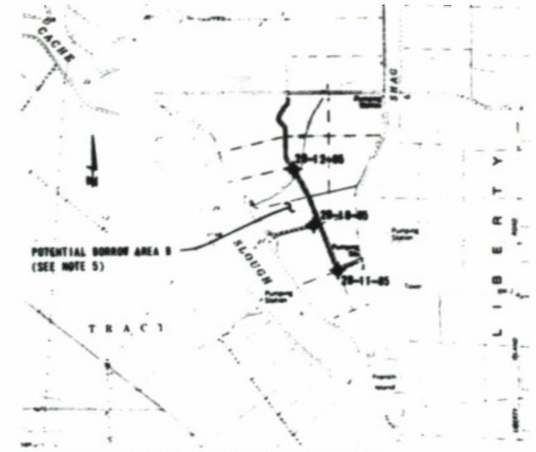
20-12-85

USCS	SAMPLE	DESCRIPTION
CH	1	Sandy CLAY: brown, mottled red-brown; moist; high plasticity.
CH	3	Wet. 8.0: grades to gray.
	3	Wet.
	4	▽ 4/16/85



BASE FROM USGS CALIFORNIA, 7.5 MINUTE SERIES, SAXON (1952), CLARKSBURG (1967), LIBERTY ISLAND (1978), AND COURTLAND (1978) TOPOGRAPHIC QUADRANGLES, REDUCED IN SCALE.

EXPLORATION LOCATION MAP - POTENTIAL BORROW AREA A
SCALE: 1"=1 MILE



BASE FROM USGS CALIFORNIA, 7.5 MINUTE SERIES, LIBERTY ISLAND TOPOGRAPHIC QUADRANGLE, 1978.

EXPLORATION LOCATION MAP - POTENTIAL BORROW AREA B
SCALE: 1"=2000'

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487)

MAJOR DIVISIONS		GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS	GRAVELS	GW	[illegible]
		GP	[illegible]
		GM	[illegible]
		GC	[illegible]
	SANDS	SW	[illegible]
		SP	[illegible]
		SM	[illegible]
		SC	[illegible]
FINE GRAINED SOILS	SILTS & CLAYS	ML	[illegible]
		CL	[illegible]
		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS & CLAYS	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
		CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
		OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS		Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS

LEGEND

- ◆ BORING LOCATION
- FI FINES, PERCENT BY WEIGHT PASSING THE NO. 200 SIEVE
- SA SAND, PERCENT BY WEIGHT PASSING THE NO. 4 SIEVE AND RETAINED ON THE NO. 200 SIEVE
- GR GRAVEL, PERCENT BY WEIGHT PASSING THE 3-INCH SIEVE AND RETAINED ON THE NO. 4 SIEVE
- PL PLASTIC LIMIT, PERCENT
- LL LIQUID LIMIT, PERCENT
- PI PLASTICITY INDEX (LL - PL), PERCENT
- MC FIELD MOISTURE CONTENT, PERCENT OF DRY WEIGHT
- G_s SPECIFIC GRAVITY (MINUS NO. 4 SIEVE MATERIAL)
- ▽ MEASURED GROUNDWATER LEVEL

NOTES:

1. BORINGS DRILLED WITH MOBILE B-53 DRILL RIG USING A 7-INCH DIAMETER HOLLOW STEM AUGER ON APRIL 16 AND 18, 1985.
2. SOIL CLASSIFICATIONS ARE IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487).
3. SAMPLES WHICH DO NOT HAVE MECHANICAL ANALYSIS OR ATTERBERG LIMITS INDICATED ON THE BORING LOGS WERE VISUALLY CLASSIFIED.
4. THE SOIL CLASSIFICATIONS AND DESCRIPTIONS PRESENTED ON THE LOGS ARE BASED ON LABORATORY MECHANICAL ANALYSES AND ATTERBERG LIMITS, LABORATORY VISUAL CLASSIFICATIONS, AND FIELD VISUAL CLASSIFICATIONS WITH MOST WEIGHT BEING GIVEN TO LABORATORY TESTS AND LABORATORY VISUAL CLASSIFICATIONS.
5. CONSIDERING THE INFERIOR QUALITY OF MATERIAL FOR LEVEE FILL THAT WOULD COME FROM POTENTIAL BORROW AREA B AS COMPARED TO BORROW AREA A, AND THE UNCERTAINTY REGARDING LAND ACQUISITION FOR BORROW FROM AREA B, POTENTIAL BORROW AREA A IS CONSIDERED THE PRIMARY BORROW SITE. REPRESENTATIVE MATERIALS FROM BORROW AREA A WERE USED FOR THE PURPOSE OF LABORATORY TESTING AND SELECTION OF DESIGN PARAMETERS.

SCALES

1 — 0 — 1 MILE   7000 — 0 — 7000 FEET

REVISION	DATE	DESCRIPTION	BY	BY
△				
△				

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: S. H. KLINE
DRAWN: R. T. TARCZY
CHECKED: K. V. RODDA

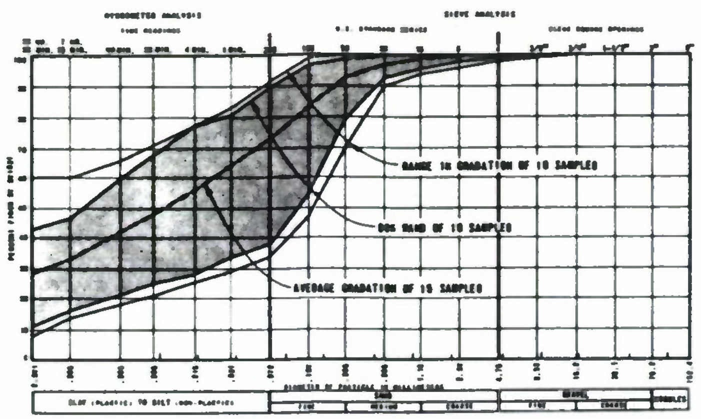
CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
BORROW INVESTIGATION
LOGS OF BORINGS

SUBMITTED: [signature]   DATE APPROVED:
SCALE: SPEC. No.
SHEET 12/21   FILE No. 50-10-5757

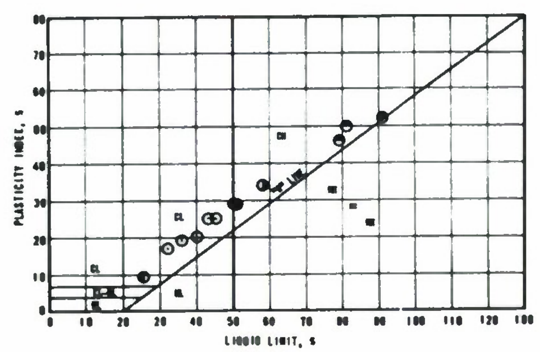
PLATE 12

SAFETY PAYS

ENVIRONMENTAL ENGINEERING

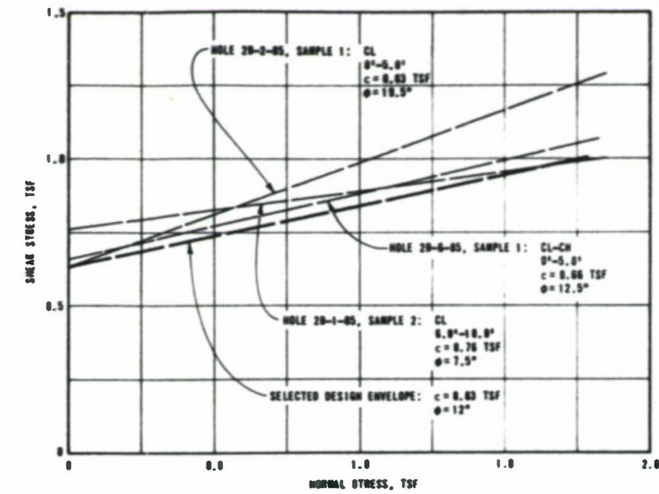


GRADATION

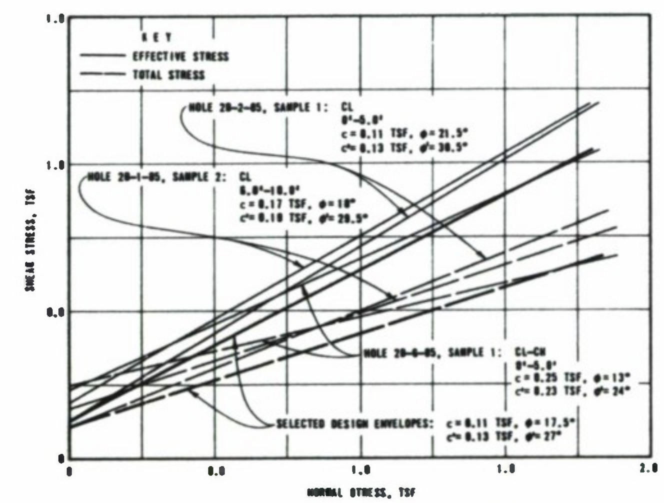


ATTERBERG LIMITS - PLASTICITY

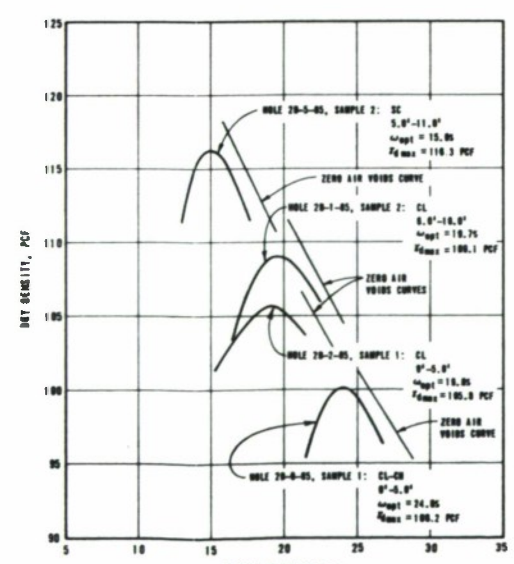
SYMBOL	HOLE	SAMPLE	DEPTH (FT)
⊙	20-1-85	1	0-5.0
		2	5.0-10.0
	20-2-85	1	0-5.0
		2	5.0-10.0
	20-3-85	1	0-5.0
●	20-4-85	1	0-5.0
	20-6-85	1	0-5.0
◐	20-5-85	1	0-5.0
◑	20-3-85	4	11.5-15.0
◒	20-10-85	1	0-5.0
		2	5.0-10.0
		3	10.0-15.0



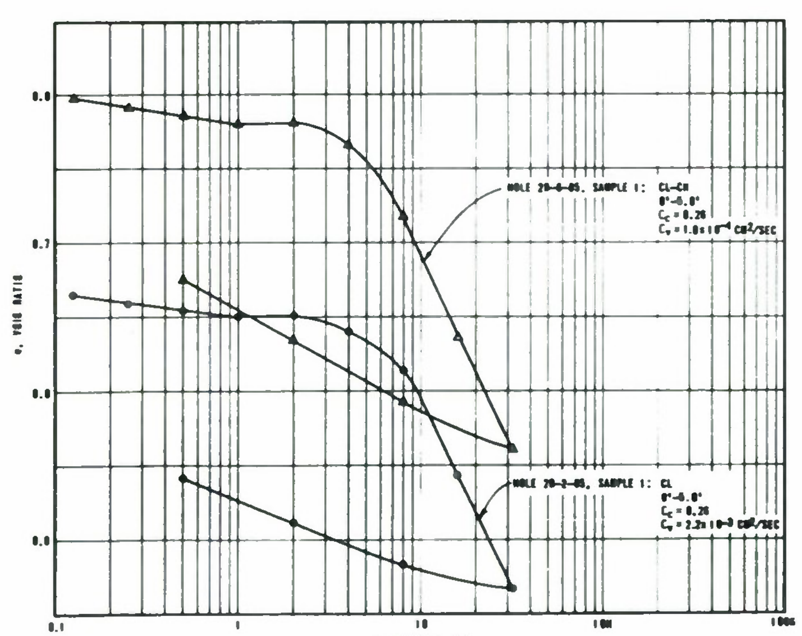
UNCONSOLIDATED UNDRAINED SHEAR STRENGTH



CONSOLIDATED UNDRAINED SHEAR STRENGTH



COMPACTION



CONSOLIDATION

PERMEABILITY					
HOLE	SAMPLE	DEPTH (FT)	SOIL TYPE[1]	CONFINING PRESSURE (PSI)	COEFFICIENT OF PERMEABILITY (CM/SEC)
20-2-85	1	0-5.0	CL	10	1.0×10^{-7}
20-5-85	2	5.0-11.0	SC	10	2.2×10^{-6}

[1] UNIFIED SOIL CLASSIFICATION SYMBOL

DESIGN PARAMETERS	
PARAMETER	SELECTED DESIGN VALUE
γ_m, MOIST DENSITY, PCF	130
c, COHESION[1], TSF	0.63
ϕ, FRICTION ANGLE[1]	12°
c, COHESION[2], TSF	0.11
ϕ, FRICTION ANGLE[2]	17.5°
c', COHESION[3], TSF	0.13
ϕ', FRICTION ANGLE[3]	27°
C_c, COMPRESSION INDEX	0.26
C_v, COEFFICIENT OF CONSOLIDATION, CM^2/SEC	2×10^{-4}
k, COEFFICIENT OF PERMEABILITY, CM/SEC	10^{-6}

[1] UNCONSOLIDATED UNDRAINED (Q ENVELOPE)
[2] CONSOLIDATED UNDRAINED - TOTAL STRESS (R ENVELOPE)
[3] CONSOLIDATED UNDRAINED - EFFECTIVE STRESS (S ENVELOPE)

NOTES:
1. COMPACTION TESTS WERE PERFORMED IN ACCORDANCE WITH ASTM D698-78, METHOD A, EQUIVALENT TO ENGINEERING MANUAL EM 1110-2-1906 STANDARD COMPACTION TEST.
2. UNCONSOLIDATED UNDRAINED AND CONSOLIDATED UNDRAINED SHEAR STRENGTH ENVELOPES ARE BASED ON THE RESULTS OF TRIAXIAL COMPRESSION TESTS.
3. TRIAXIAL COMPRESSION AND CONSOLIDATION TESTS WERE PERFORMED ON SAMPLES FABRICATED TO A DRY DENSITY EQUAL TO 95 PERCENT OF THE LABORATORY MAXIMUM DRY DENSITY AT A WATER CONTENT 2 PERCENT ABOVE OPTIMUM WATER CONTENT.
4. PERMEABILITY TESTS WERE PERFORMED ON SAMPLES FABRICATED TO A DRY DENSITY EQUAL TO 95 PERCENT OF THE LABORATORY MAXIMUM DRY DENSITY AT A WATER CONTENT 2 PERCENT ABOVE OPTIMUM WATER CONTENT, AFTER SATURATION AND CONSOLIDATION UNDER A CONFINING PRESSURE OF 10 PSI.

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
BORROW INVESTIGATION
SUMMARY OF LABORATORY TEST RESULTS

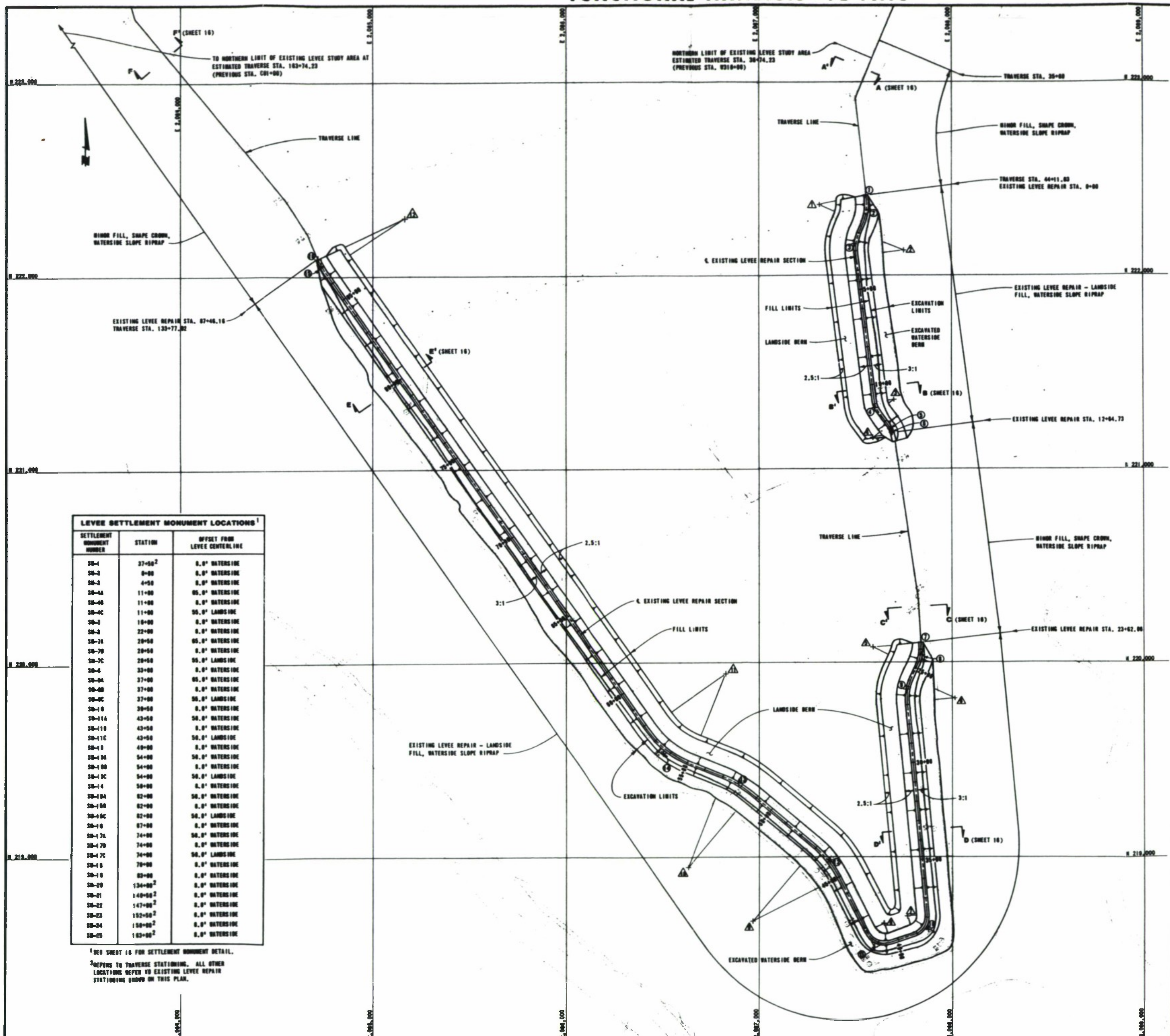
DESIGNED: D. H. KLINE
DRAWN: R. T. TARCZY
CHECKED: K. V. BOBBA
SUBMITTED:

SHEET 13/21 FILE No. 50-10-5757

SAFETY PAYS

PLATE 13

FUNCTIONAL ANALYSIS - VE PAYS



HORIZONTAL ALIGNMENT DATA				
P.I. COORDINATES[1]			BEARING	DISTANCE
PT. NO.	NORTH	EAST		
1	222,468.94	2,087,667.34		
			N 0°50'10"E	74.00
2	222,337.00	2,087,670.00		
			S 23°04'54"W	101.31
3	222,101.00	2,087,465.00		
			S 7°11'20"E	804.72
4	221,313.00	2,087,562.00		
			S 36°22'00"E	136.01
5	221,203.00	2,087,563.00		
			S 17°22'00"E	16.73
6	221,187.00	2,087,567.00		
7	220,898.72	2,087,585.07		
			S 0°00'40"E	66.00
8	220,833.00	2,087,642.00		
			S 24°50'13"W	103.04
9	219,858.00	2,087,701.00		
			S 0°18'20"E	1,240.25
10	219,623.00	2,087,675.00		
			S 71°37'07"W	291.00
11	219,531.00	2,087,360.00		
			N 87°31'00"W	518.79
12	219,894.00	2,087,362.00		
			N 40°53'43"W	918.18
13	219,376.00	2,086,883.00		
			N 66°18'20"W	418.74
14	219,534.00	2,086,564.00		
			N 39°00'30"W	3,004.74
15	222,058.00	2,084,732.00		
			N 26°33'36"W	67.10
16	222,082.34	2,084,716.36		

[1] COORDINATES AT POINTS 1, 6, 8 AND 16 ARE NOT P.I. COORDINATES, BUT CORRESPOND TO POINTS AT THE ENDS OF CURVES.

CURVE DATA				
CURVE NO.	RADIUS	Δ	TANGENT	CURVE LENGTH
1	250.00'	33°00'00"	74.00	148.00
2	250.00'	30°10'10"	67.82	188.00
3	100.00'	29°10'31"	26.00	50.92
4	100.00'	18°00'00"	16.73	33.16
5	250.00'	30°00'00"	66.00	130.00
6	250.00'	30°00'41"	67.25	131.00
7	100.00'	78°34'03"	79.40	134.22
8	100.00'	80°51'10"	85.10	141.10
9	500.00'	22°22'30"	98.00	190.00
10	500.00'	18°22'40"	80.00	160.30
11	500.00'	33°10'51"	148.16	290.00
12	500.00'	8°30'00"	37.16	74.16

NOTES:
1. BASE WAS REPRODUCED FROM TOPOGRAPHY PREPARED BY FALCONI AND ASSOCIATES AND SUPPLIED BY SACRAMENTO DISTRICT CORPS OF ENGINEERS REDUCED FROM ORIGINAL 1" = 100' SCALE TO 1" = 200' SCALE.
2. GRID COORDINATES REFER TO CALIFORNIA STATE COORDINATE SYSTEM, ZONE II.
3. ELEVATIONS ON THE TOPOGRAPHIC BASE REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929 WHICH IS 3 FOOT ABOVE CORPS OF ENGINEERS DATUM AT THIS SITE.
4. HORIZONTAL ALIGNMENT AND CURVE DATA PROVIDED ON THIS DRAWING REFERS TO THE EXISTING LEVEE LANDSIDE FILL REPAIR SECTIONS. REFER TO SHEET 8 FOR TRAVERSE ALIGNMENT DATA.

SCALE
200 0 200 FEET

LEVEE SETTLEMENT MONUMENT LOCATIONS[1]		
SETTLEMENT MONUMENT NUMBER	STATION	OFFSET FROM LEVEE CENTERLINE
SM-1	37+50[2]	8.0' WATERSIDE
SM-2	0+00	8.0' WATERSIDE
SM-3	4+50	8.0' WATERSIDE
SM-4A	11+00	65.0' WATERSIDE
SM-4B	11+00	8.0' WATERSIDE
SM-4C	11+00	55.0' LANDSIDE
SM-5	16+00	8.0' WATERSIDE
SM-6	22+00	8.0' WATERSIDE
SM-7A	28+50	65.0' WATERSIDE
SM-7B	28+50	8.0' WATERSIDE
SM-7C	28+50	55.0' LANDSIDE
SM-8	33+00	8.0' WATERSIDE
SM-9A	37+00	65.0' WATERSIDE
SM-9B	37+00	8.0' WATERSIDE
SM-9C	37+00	55.0' LANDSIDE
SM-10	39+50	8.0' WATERSIDE
SM-11A	43+50	50.0' WATERSIDE
SM-11B	43+50	8.0' WATERSIDE
SM-11C	43+50	50.0' LANDSIDE
SM-12	49+00	8.0' WATERSIDE
SM-13A	54+00	50.0' WATERSIDE
SM-13B	54+00	8.0' WATERSIDE
SM-13C	54+00	50.0' LANDSIDE
SM-14	58+00	8.0' WATERSIDE
SM-15A	62+00	50.0' WATERSIDE
SM-15B	62+00	8.0' WATERSIDE
SM-15C	62+00	50.0' LANDSIDE
SM-16	67+00	8.0' WATERSIDE
SM-17A	74+00	50.0' WATERSIDE
SM-17B	74+00	8.0' WATERSIDE
SM-17C	74+00	50.0' LANDSIDE
SM-18	78+00	8.0' WATERSIDE
SM-19	83+00	8.0' WATERSIDE
SM-20	134+00[2]	8.0' WATERSIDE
SM-21	140+50[2]	8.0' WATERSIDE
SM-22	147+00[2]	8.0' WATERSIDE
SM-23	152+50[2]	8.0' WATERSIDE
SM-24	158+00[2]	8.0' WATERSIDE
SM-25	163+00[2]	8.0' WATERSIDE

[1] SEE SHEET 16 FOR SETTLEMENT MONUMENT DETAIL.

[2] REFERS TO TRAVERSE STATIONING. ALL OTHER LOCATIONS REFER TO EXISTING LEVEE REPAIR STATIONING SHOWN ON THIS PLAN.

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
EXISTING LEVEE REPAIR DESIGN
PLAN

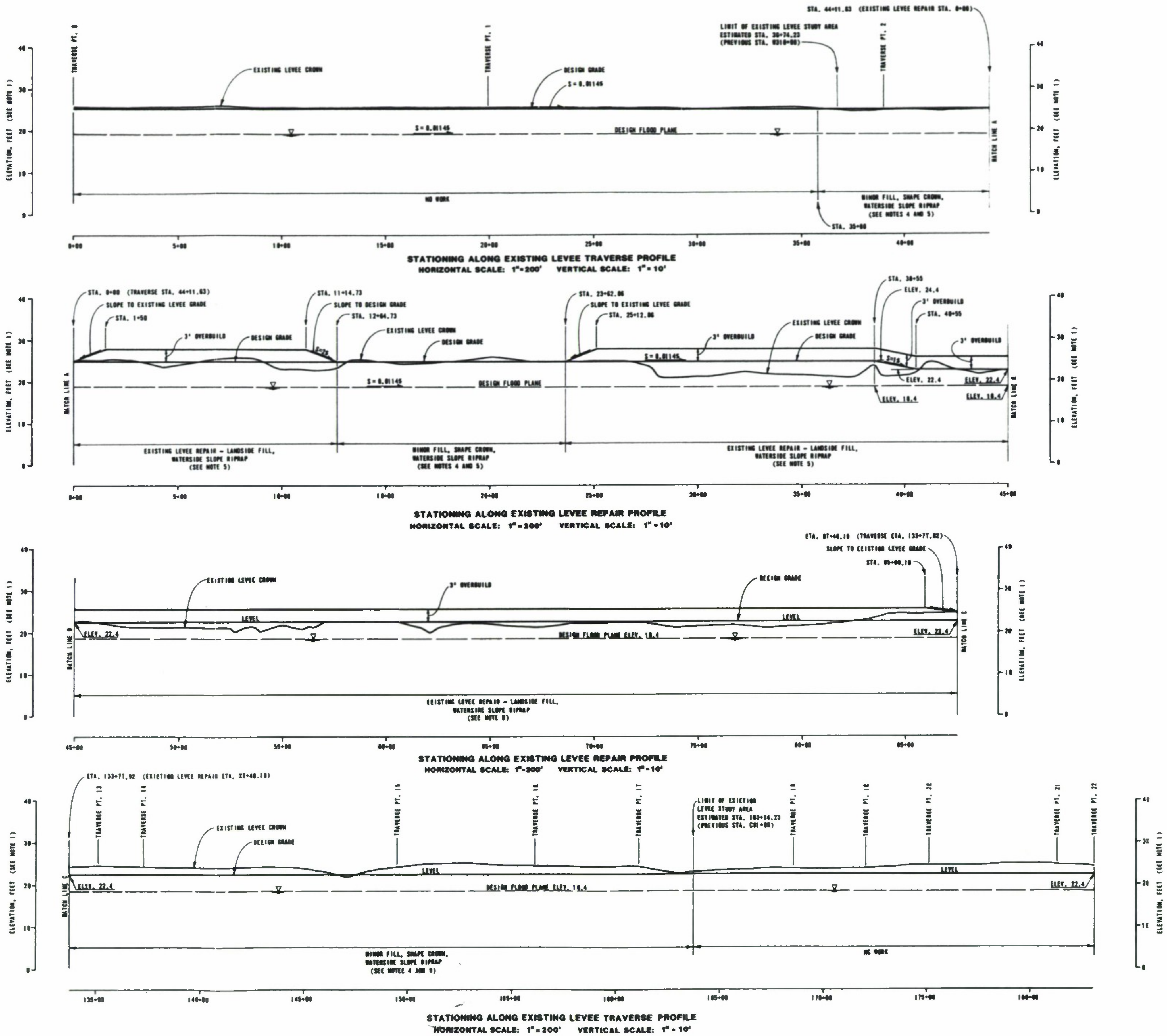
DESIGNED: S. R. KLINE
DRAWN: R. T. TARCZY
CHECKED: K. Y. MOORA
SUBMITTED:

SHEET 14/21 | FILE No. 50-10-5757

SAFETY PAYS

PLATE 14

FUNCTIONAL ANALYSIS - VE PAYS



NOTES:

1. ELEVATIONS REFER TO CORPS OF ENGINEERS DATUM WHICH IS 3 FEET BELOW NATIONAL GEODETIC VERTICAL DATUM OF 1929 AT THIS SITE.
2. THE EXISTING LEVEE CROWN IS A PROJECTION OF THE MAXIMUM LEVEE GRADE FROM TOPOGRAPHIC MAPS ONTO THE TRAVERSE AND EXISTING LEVEE REPAIR PROFILES.
3. REFER TO SHEET 2 FOR TRAVERSE ALIGNMENT DATA. REFER TO SHEET 14 FOR EXISTING LEVEE LANDSIDE FILL REPAIR SECTION ALIGNMENT DATA.
4. WITHIN THE SECTIONS WHERE MINOR FILL AND SHAPING OF THE EXISTING LEVEE CROWN ARE CALLED FOR, THIS WORK IS ONLY REQUIRED TO BRING THE EXISTING LEVEE GRADE UP TO DESIGN GRADE IN AREAS WHERE A 20-FOOT CROWN WIDTH AT DESIGN GRADE DOES NOT ALREADY EXIST. NO WORK IS REQUIRED WITHIN THESE AREAS WHERE THE CROWN WIDTH AND THE EXISTING GRADE ARE NOT DEFICIENT.
5. RIPRAP IS CALLED FOR FOR WATERSIDE SLOPE PROTECTION WITHIN THE ENTIRE EXISTING LEVEE STUDY AREA. THIS WORK IS REQUIRED WHERE RIPRAP DOES NOT ALREADY EXIST.

SCALES

200 0 200 FEET HORIZONTAL

10 0 10 FEET VERTICAL

REVISION	DATE	DESCRIPTION	BY	BY

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: S. R. KLINE
DRAWN: R. T. TARCZY
CHECKED: R. V RUDDA

CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES

EXISTING LEVEE REPAIR DESIGN

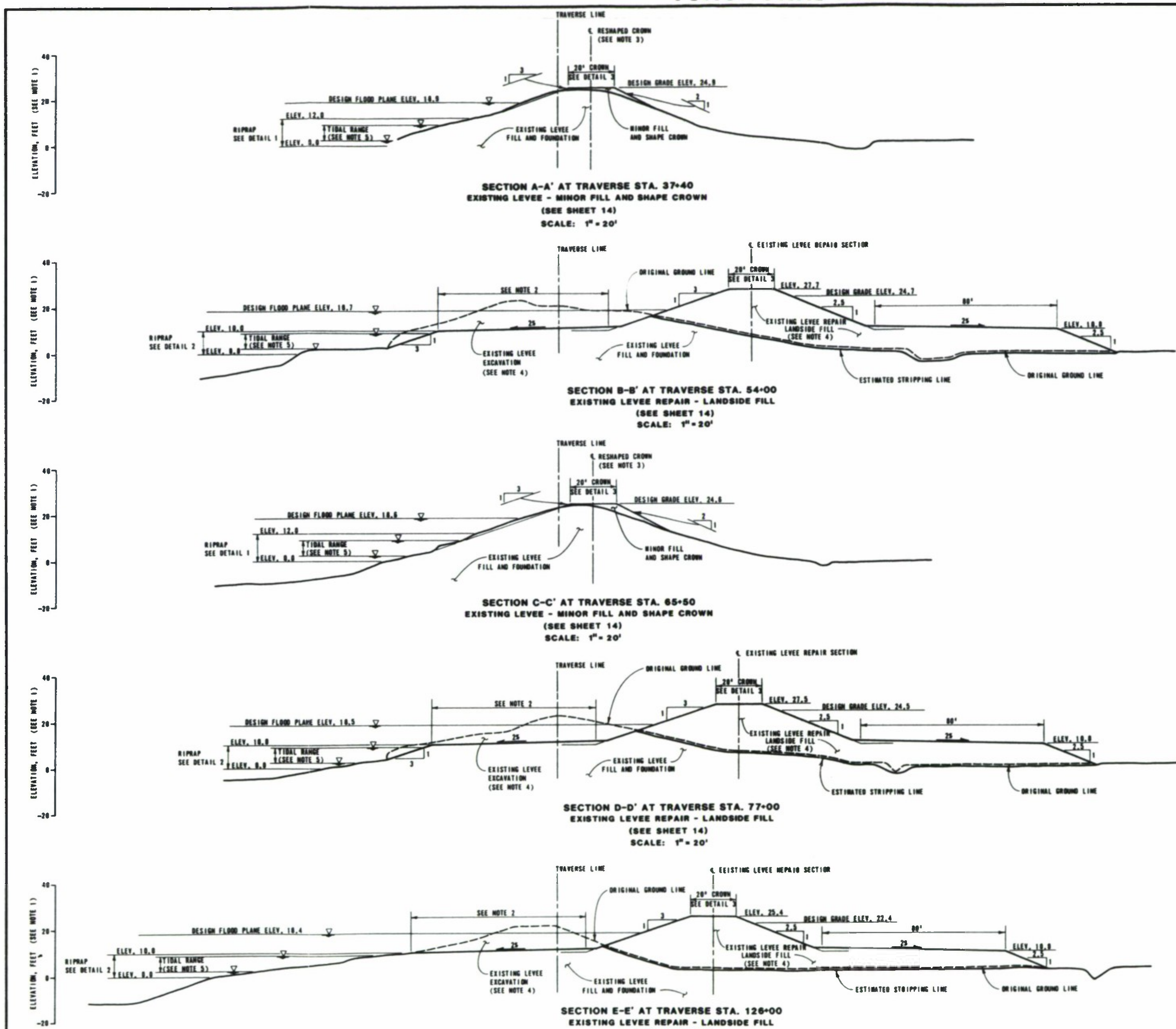
PROFILE

SHEET 15/21 FILE No. 50-10-5757

PLATE 15

SAFETY PAYS

FUNCTIONAL ANALYSIS - VE PAYS



SECTION A-A' AT TRAVERSE STA. 37+40
EXISTING LEVEE - MINOR FILL AND SHAPE CROWN
(SEE SHEET 14)
SCALE: 1" = 20'

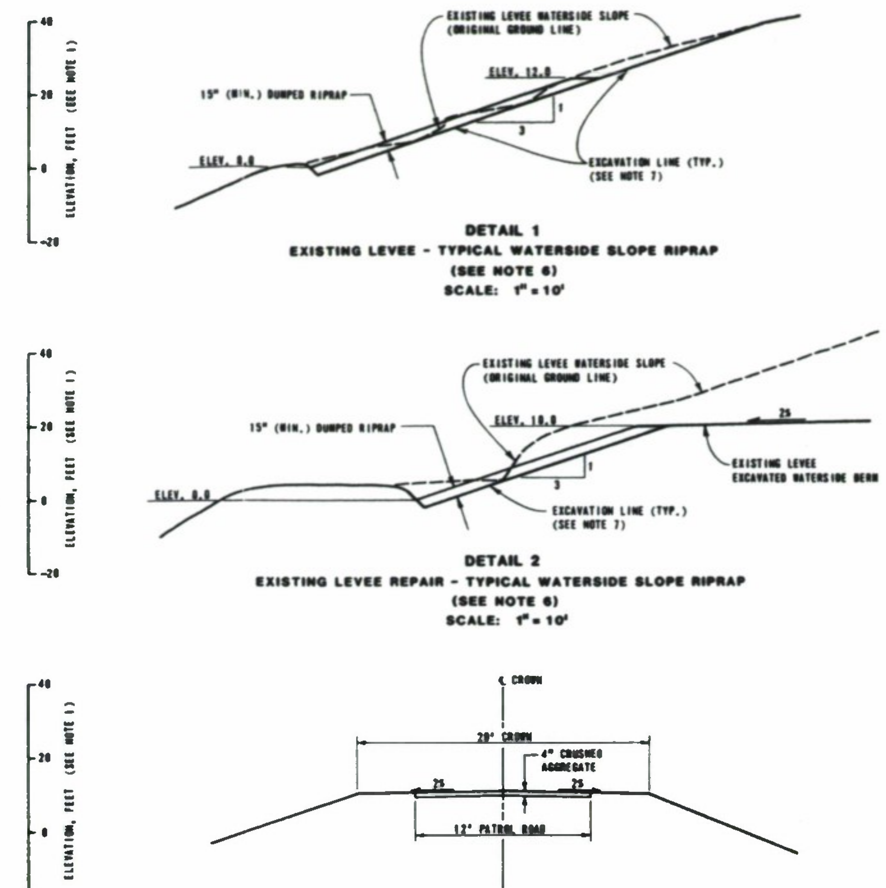
SECTION B-B' AT TRAVERSE STA. 54+00
EXISTING LEVEE REPAIR - LANDSIDE FILL
(SEE SHEET 14)
SCALE: 1" = 20'

SECTION C-C' AT TRAVERSE STA. 65+50
EXISTING LEVEE - MINOR FILL AND SHAPE CROWN
(SEE SHEET 14)
SCALE: 1" = 20'

SECTION D-D' AT TRAVERSE STA. 77+00
EXISTING LEVEE REPAIR - LANDSIDE FILL
(SEE SHEET 14)
SCALE: 1" = 20'

SECTION E-E' AT TRAVERSE STA. 126+00
EXISTING LEVEE REPAIR - LANDSIDE FILL
(SEE SHEET 14)
SCALE: 1" = 20'

SECTION F-F' AT TRAVERSE STA. 146+85
EXISTING LEVEE - MINOR FILL AND SHAPE CROWN
(SEE SHEET 14)
SCALE: 1" = 20'



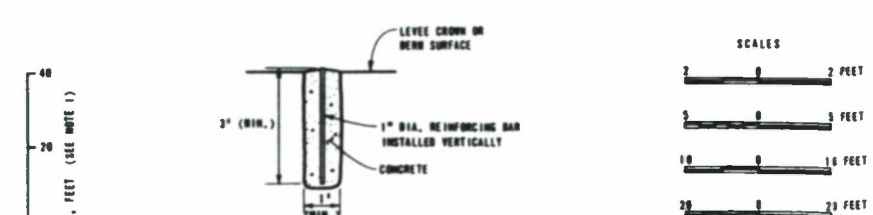
DETAIL 1
EXISTING LEVEE - TYPICAL WATERSIDE SLOPE RIPRAP
(SEE NOTE 6)
SCALE: 1" = 10'

DETAIL 2
EXISTING LEVEE REPAIR - TYPICAL WATERSIDE SLOPE RIPRAP
(SEE NOTE 6)
SCALE: 1" = 10'

DETAIL 3
LEVEE CROWN
SCALE: 1" = 5'

NOTES:

1. ELEVATIONS REFER TO CORPS OF ENGINEERS DATUM WHICH IS 3 FEET BELOW NATIONAL GEODETIC VERTICAL DATUM OF 1929 AT THIS SITE.
2. THE CRITICAL CRITERIA FOR THE LOCATION OF THE EXISTING LEVEE REPAIR LANDSIDE FILL IS THAT THE EXCAVATED WATERSIDE BERM HAVE A MINIMUM WIDTH OF 50 FEET. THE SELECTED ALIGNMENT PRESENTED ON SHEET 14 IS EXPECTED TO PROVIDE FOR THIS BUT SHOULD BE VERIFIED IN THE FIELD DURING CONSTRUCTION AND ADJUSTMENTS MADE WHERE NECESSARY.
3. THE ALIGNMENT OF THE LEVEE CROWN WHERE ONLY MINOR FILL AND SHAPING OF THE CROWN ARE REQUIRED IS CONTROLLED BY MAINTAINING AN OVERALL EFFECTIVE WATERSIDE SLOPE OF 3 HORIZONTAL TO 1 VERTICAL AS ILLUSTRATED BY SECTIONS A-A', C-C', AND F-F'.
4. THE DESIGN OF THE EXISTING LEVEE REPAIR LANDSIDE FILL IS BASED ON THE PRIMARY SOURCE OF FILL BEING DERIVED FROM POTENTIAL BORROW AREA A (SHEET 12). THE INCORPORATION OF MATERIAL EXCAVATED FROM THE EXISTING LEVEE TO FORM THE WATERSIDE BERM INTO THE NEW LANDSIDE FILL IS ALLOWED ONLY IN THE LANDSIDE BERM.
5. THE TIDAL RANGE INDICATED ON THE SECTIONS IS BASED ON CURRENT TIDAL INFORMATION FOR THE LOCATION OF RIO VISTA, ADJUSTED FOR THIS SITE BY ADDING 0.3 FEET AS PER THE CORPS OF ENGINEERS DIRECTION. THIS RESULTS IN A MAXIMUM TIDAL RANGE FROM ELEVATION 2.5 TO ELEVATION 8.2 (CORPS OF ENGINEERS DATUM).
6. RIPRAP IS CALLED FOR FOR WATERSIDE SLOPE PROTECTION WITHIN THE ENTIRE EXISTING LEVEE STUDY AREA. THIS WORK IS REQUIRED WHERE RIPRAP DOES NOT ALREADY EXIST.
7. EXCAVATION AND SHAPING OF THE EXISTING LEVEE WATERSIDE SLOPE TO A TYPICAL 3 HORIZONTAL TO 1 VERTICAL SLOPE, AS ILLUSTRATED BY TYPICAL DETAILS 1 AND 2, IS REQUIRED WHERE SLOUGHING AND CAVING HAVE CREATED LOCALLY OVERSTEEPENED SLOPES, IN ORDER TO PROVIDE AN ADEQUATE SURFACE FOR RIPRAP PLACEMENT. ONLY SHAPING TO SMOOTH IRREGULARITIES IS REQUIRED WHERE THE EXISTING SLOPE IN THE AREA TO RECEIVE RIPRAP IS ALREADY 3 HORIZONTAL TO 1 VERTICAL OR FLATTER.



DETAIL 4
SETTLEMENT MONUMENT
(SEE SHEET 14)
SCALE: 1" = 2'

DESIGNED	S. B. SLIDE
DRAWN	B. T. TARCZY
CHECKED	R. V. DUBOA

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

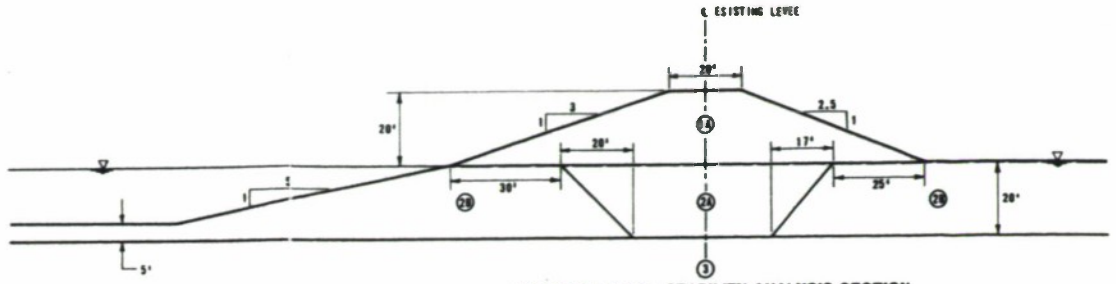
CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
EXISTING LEVEE REPAIR DESIGN
SECTIONS AND DETAILS

SHEET 16/21 FILE No. 50-10-5757

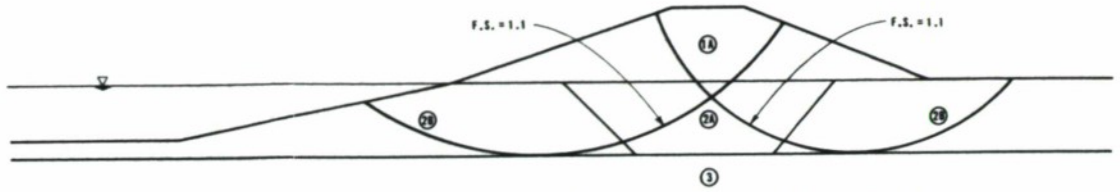
PLATE 18

SAFETY PAYS

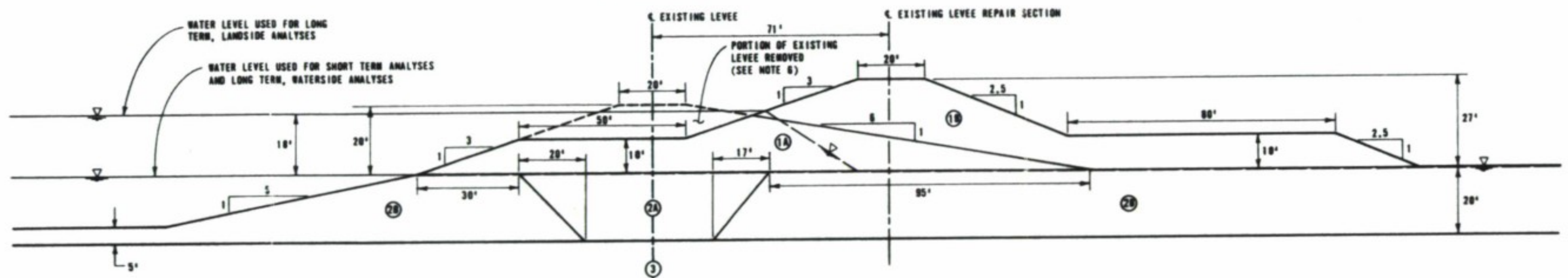
FUNCTIONAL ANALYSIS - VE PAYS



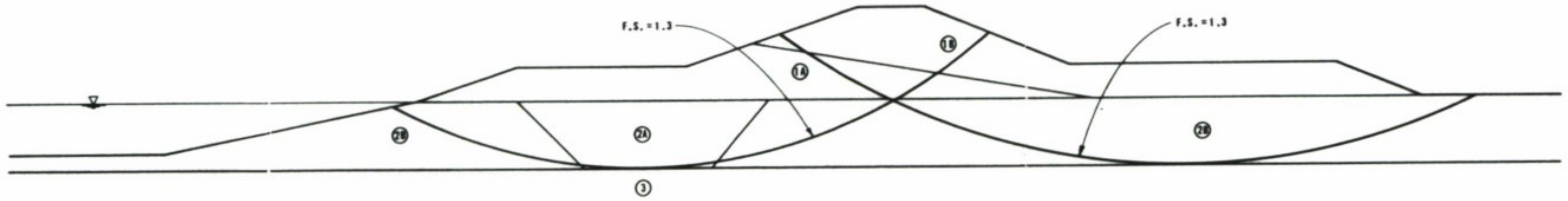
EXISTING LEVEE - STABILITY ANALYSIS SECTION
SCALE: 1" = 20'



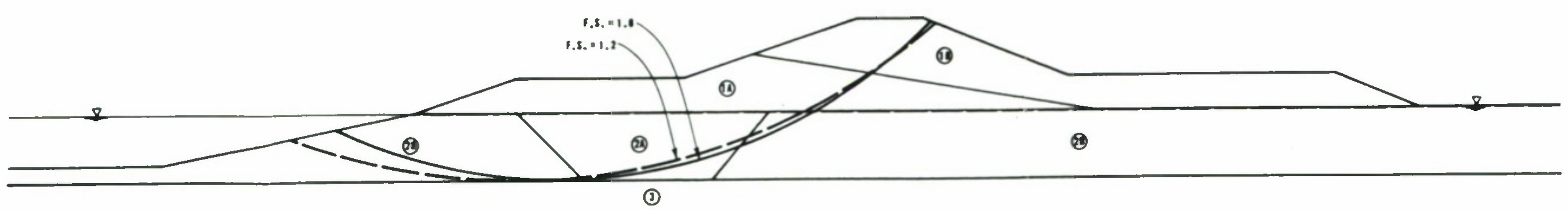
EXISTING LEVEE - STABILITY ANALYSIS RESULTS
(SEE NOTE 4)
SCALE: 1" = 20'



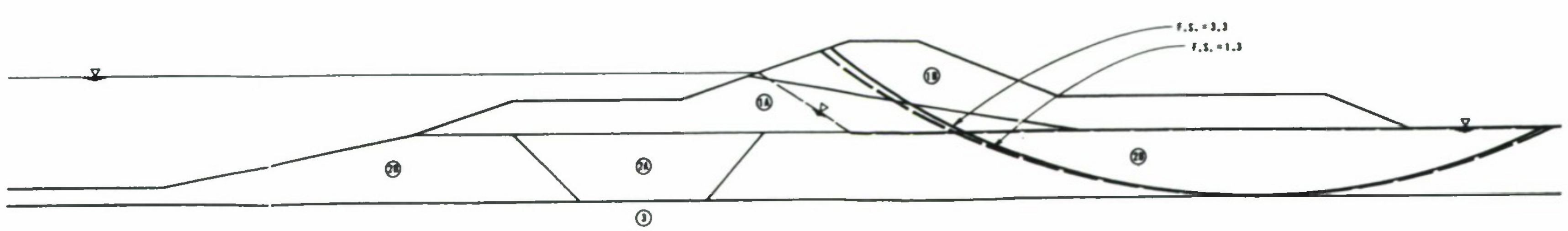
EXISTING LEVEE REPAIR - STABILITY ANALYSIS SECTION
SCALE: 1" = 20'



EXISTING LEVEE REPAIR - STABILITY ANALYSIS RESULTS
END OF CONSTRUCTION
SCALE: 1" = 20'



EXISTING LEVEE REPAIR - STABILITY ANALYSIS RESULTS
LONG TERM AND EARTHQUAKE - WATERSIDE SLOPE
SCALE: 1" = 20'



EXISTING LEVEE REPAIR - STABILITY ANALYSIS RESULTS
LONG TERM AND EARTHQUAKE - LANDSIDE SLOPE
SCALE: 1" = 20'

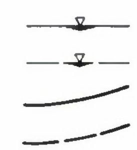
SOIL PARAMETERS USED IN STABILITY ANALYSES

MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT (pcf)	SHEAR STRENGTH: END OF CONSTRUCTION: COHESION (psf)	SHEAR STRENGTH: END OF CONSTRUCTION: FRICTION ANGLE (degrees)	SHEAR STRENGTH: LONG TERM AND EARTHQUAKE: COHESION (psf)	SHEAR STRENGTH: LONG TERM AND EARTHQUAKE: FRICTION ANGLE (degrees)
1A	FILL - EXISTING LEVEE	110	800	0	200	30.5
1B	FILL - BORROW (SEE NOTE 6)	130	1200	12	340	22.25
2A	SOFTER FOUNDATION - BENEATH EXISTING LEVEE	95	450	0	300	10
2B	SOFTER FOUNDATION - BEYOND TOE OF EXISTING LEVEE	85	300	0	200	10
3	STIFFER FOUNDATION	125	SEE NOTE 5			

SUMMARY OF STABILITY ANALYSES RESULTS

CONDITION	REQUIRED MINIMUM FACTOR OF SAFETY	CALCULATED MINIMUM FACTOR OF SAFETY: WATERSIDE SLOPE	CALCULATED MINIMUM FACTOR OF SAFETY: LANDSIDE SLOPE
EXISTING LEVEE (SEE NOTE 4)	N/A	1.1	1.1
EXISTING LEVEE REPAIR			
END OF CONSTRUCTION	1.3	1.3	1.3
LONG TERM - STATIC	1.4	1.8	3.3
LONG TERM - PSEUDOSTATIC (0.1g)	1.0	1.3	1.3

LEGEND



- ASSUMED WATER LEVEL
- ASSUMED PHREATIC SURFACE
- CRITICAL CIRCLE - STATIC
- CRITICAL CIRCLE - PSEUDOSTATIC (SEISMIC COEFFICIENT = 0.1g)

NOTES:

1. SHEAR STRENGTH PARAMETERS USED IN THE STABILITY ANALYSES AND REQUIRED MINIMUM FACTORS OF SAFETY FOR VARIOUS CONDITIONS OF ANALYSIS ARE IN ACCORDANCE WITH SLOPE STABILITY CRITERIA IN ENGINEERING MANUAL EM 1110 - 2 - 1913, DESIGN AND CONSTRUCTION OF LEVEES.
2. STABILITY ANALYSES RESULTS FACTORS OF SAFETY WERE DETERMINED USING BISHOP'S MODIFIED METHOD FOR CIRCULAR ARC ANALYSIS.
3. BECAUSE OF THE SIGNIFICANTLY GREATER STRENGTH IN THE STIFFER FOUNDATION, STABILITY ANALYSES WERE PERFORMED SUCH THAT POTENTIAL FAILURE SURFACES REMAIN WITHIN THE SOFTER FOUNDATION AND DO NOT PASS THROUGH THE UNDERLYING STIFFER FOUNDATION. THEREFORE, IDENTIFICATION OF SHEAR STRENGTH PARAMETERS FOR THE STIFFER FOUNDATION FOR USE IN STABILITY ANALYSES IS NOT NECESSARY.
4. SHEAR STRENGTH PARAMETERS USED IN THE EXISTING LEVEE STABILITY ANALYSIS ARE END OF CONSTRUCTION PARAMETERS WHICH REPRESENT IN SITU UNDRAINED STRENGTHS.
5. NO PHREATIC SURFACE WAS USED IN THE EXISTING LEVEE AND EXISTING LEVEE REPAIR, END OF CONSTRUCTION STABILITY ANALYSES FOR THE PURPOSE OF DEFINING PORE PRESSURES BECAUSE THESE ARE TOTAL STRESS ANALYSES BASED ON TOTAL STRESS STRENGTH PARAMETERS.
6. THE STABILITY ANALYSIS OF THE EXISTING LEVEE REPAIR SECTION IS BASED ON BORROW BEING DERIVED FROM POTENTIAL BORROW AREA A (SHEET 13). THE INCORPORATION OF MATERIAL EXCAVATED FROM THE EXISTING LEVEE TO FORM THE WATERSIDE BERM INTO THE NEW LANDSIDE FILL WOULD BE ALLOWED IN THE LANDSIDE BERM.

SCALE

20 0 20 FEET

REVISION	DATE	DESCRIPTION	BY

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: S. H. KLINE
DRAWN: H. T. TARCZY
CHECKED: B. V. BUBBA

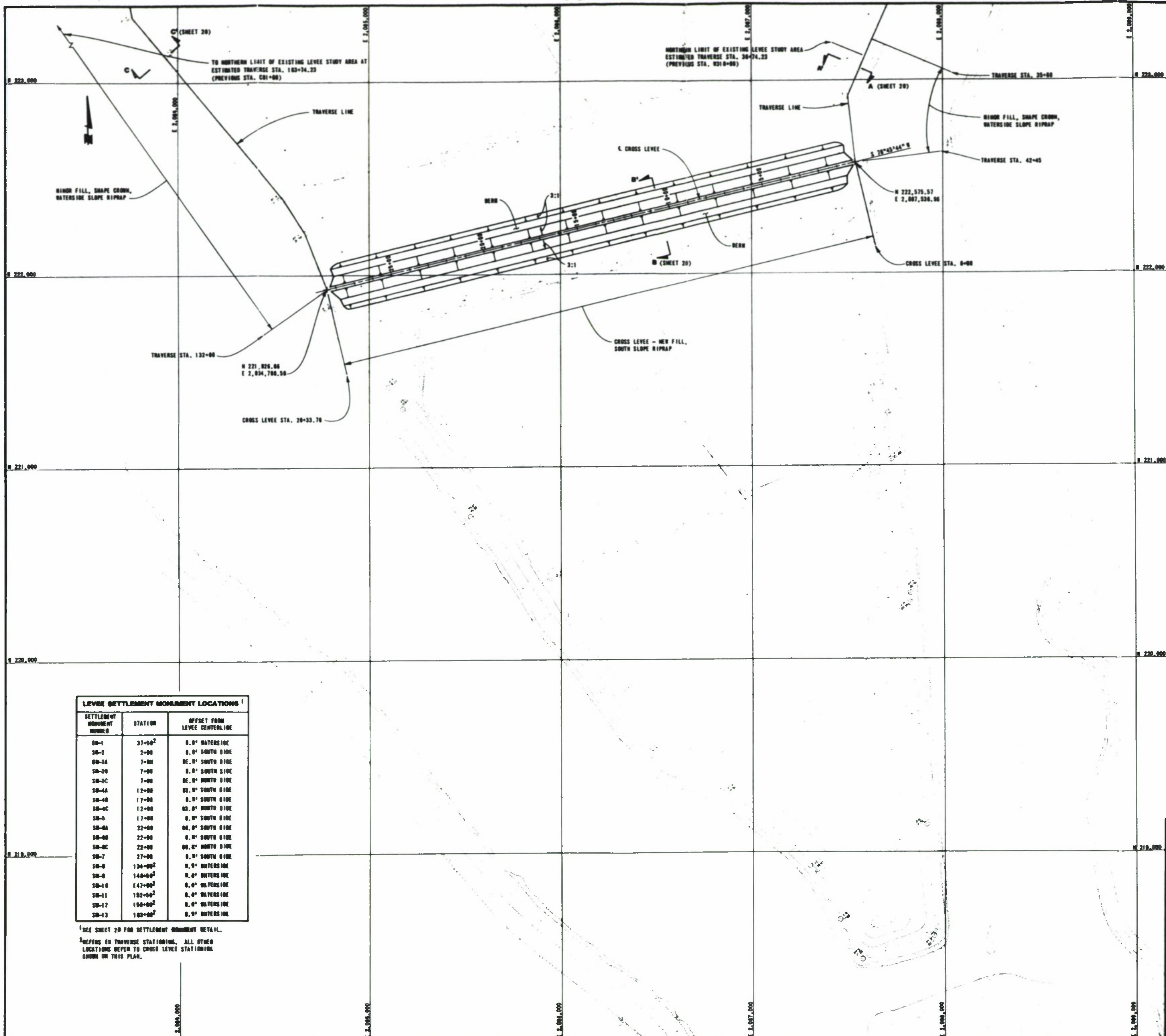
CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
EXISTING LEVEE REPAIR DESIGN
STABILITY ANALYSES RESULTS

SUBMITTED:
DATE APPROVED:
SCALE:
SPEC. No.
SHEET 17/21
FILE No. 50-10-5757

PLATE 17

SAFETY PAYS

FUNCTIONAL ANALYSIS - VE PAYS



LEVEE SETTLEMENT MONUMENT LOCATIONS [1]		
SETTLEMENT MONUMENT NUMBER	STATION	OFFSET FROM LEVEE CENTERLINE
SB-1	37+50[2]	0.0' WATERSIDE
SB-2	2+00	0.0' SOUTH SIDE
SB-3A	7+00	65.0' SOUTH SIDE
SB-3B	7+00	0.0' SOUTH SIDE
SB-3C	7+00	65.0' NORTH SIDE
SB-4A	12+00	63.0' SOUTH SIDE
SB-4B	17+00	0.0' SOUTH SIDE
SB-4C	12+00	63.0' NORTH SIDE
SB-5	17+00	0.0' SOUTH SIDE
SB-6A	22+00	60.0' SOUTH SIDE
SB-6B	22+00	0.0' SOUTH SIDE
SB-6C	22+00	60.0' NORTH SIDE
SB-7	27+00	0.0' SOUTH SIDE
SB-8	134+00[2]	0.0' WATERSIDE
SB-9	140+00[2]	0.0' WATERSIDE
SB-10	147+00[2]	0.0' WATERSIDE
SB-11	152+50[2]	0.0' WATERSIDE
SB-12	158+00[2]	0.0' WATERSIDE
SB-13	163+00[2]	0.0' WATERSIDE

[1] SEE SHEET 20 FOR SETTLEMENT MONUMENT DETAIL.

[2] REFERS TO TRAVERSE STATIONING. ALL OTHER LOCATIONS REFER TO CROSS LEVEE STATIONING SHOWN ON THIS PLAN.

NOTES:
1. BASE WAS REPRODUCED FROM TOPOGRAPHY PREPARED BY FALCONI AND ASSOCIATES AND SUPPLIED BY SACRAMENTO DISTRICT CORPS OF ENGINEERS REDUCED FROM ORIGINAL 1" = 100' SCALE TO 1" = 200' SCALE.
2. GRID COORDINATES REFER TO CALIFORNIA STATE COORDINATE SYSTEM, ZONE II.
3. ELEVATIONS ON THE TOPOGRAPHIC BASE REFER TO NATIONAL GEODETIC VERTICAL DATUM OF 1929 WHICH IS 3 FEET ABOVE CORPS OF ENGINEERS DATUM AT THIS SITE.
4. HORIZONTAL ALIGNMENT DATA PROVIDED ON THIS DRAWING REFERS TO THE CROSS LEVEE SECTION. REFER TO SHEET 2 FOR TRAVERSE ALIGNMENT DATA.

REVISION	DATE	DESCRIPTION	BY

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

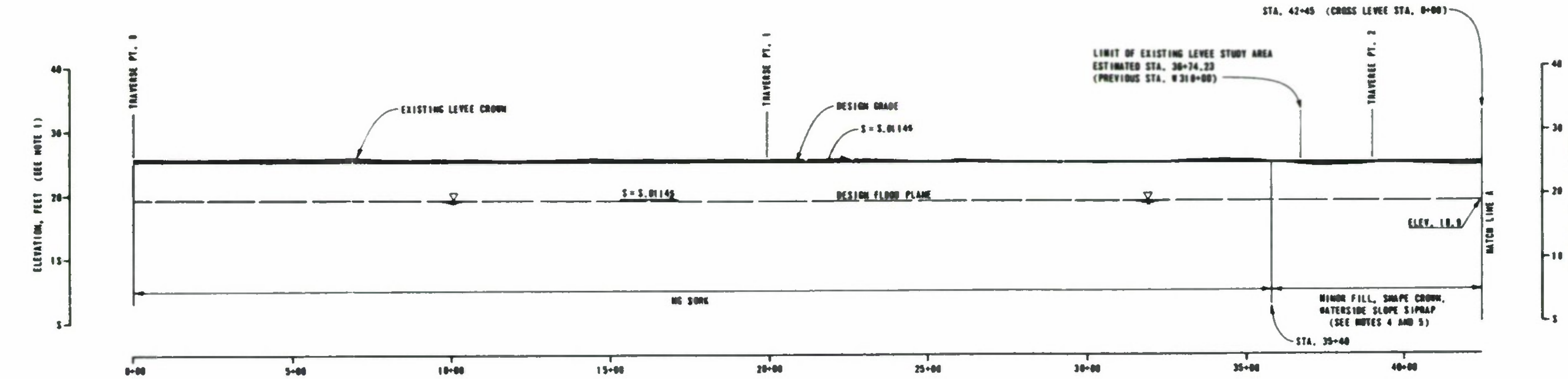
DESIGNED: S. H. KLINE
DRAWN: R. T. TARCZY
CHECKED: K. V. BONDA
SUBMITTED:

CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
CROSS LEVEE DESIGN
PLAN

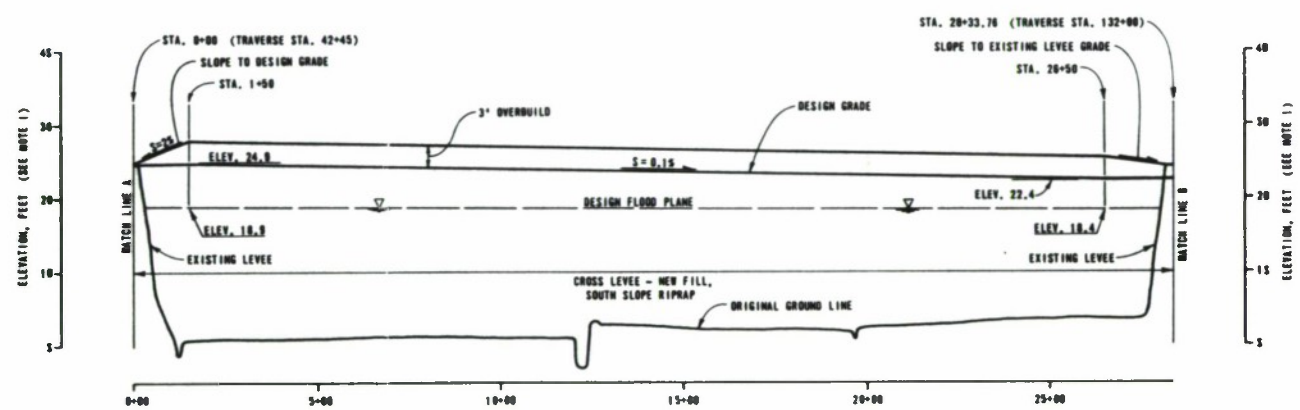
DATE APPROVED:
SCALE:
SPEC. No.
SHEET 18/21
FILE No. 50-10-5757

PLATE 18

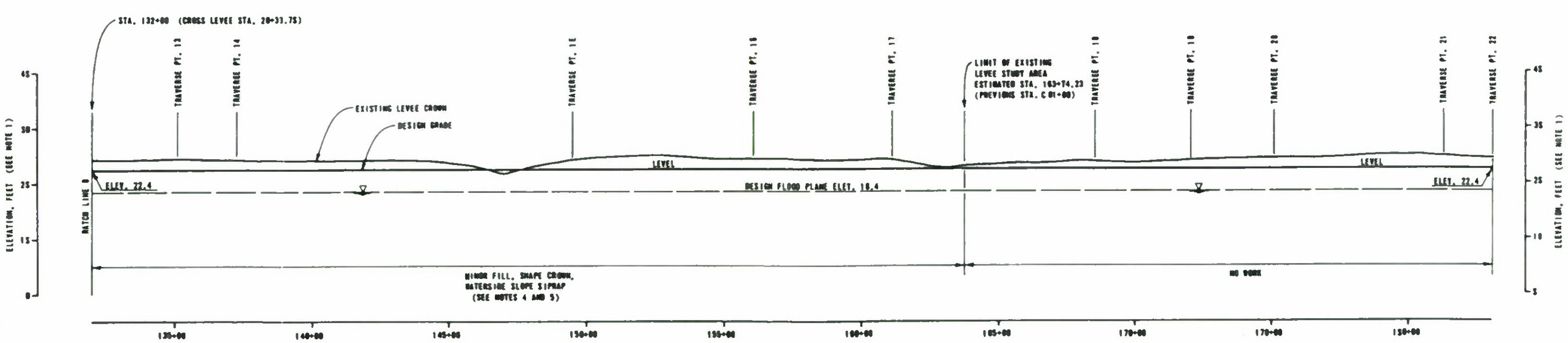
SAFETY PAYS



STATIONING ALONG EXISTING LEVEE TRAVERSE PROFILE
HORIZONTAL SCALE: 1" = 200' VERTICAL SCALE: 1" = 10'



STATIONING ALONG CROSS LEVEE PROFILE
HORIZONTAL SCALE: 1" = 200' VERTICAL SCALE: 1" = 10'

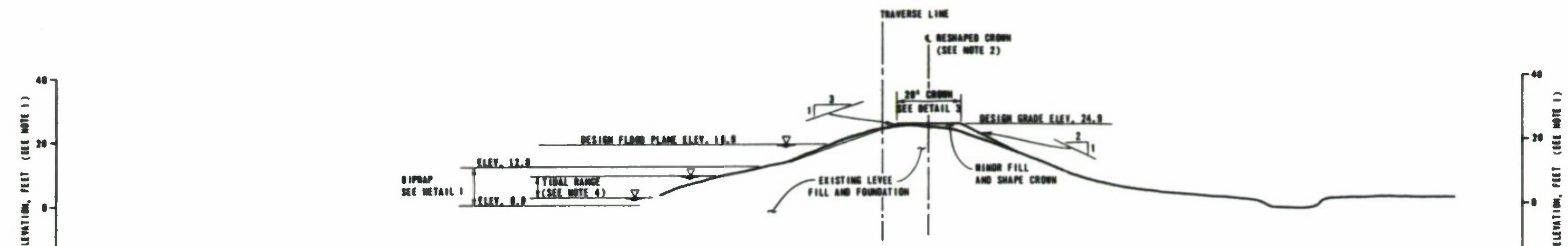


STATIONING ALONG EXISTING LEVEE TRAVERSE PROFILE
HORIZONTAL SCALE: 1" = 200' VERTICAL SCALE: 1" = 10'

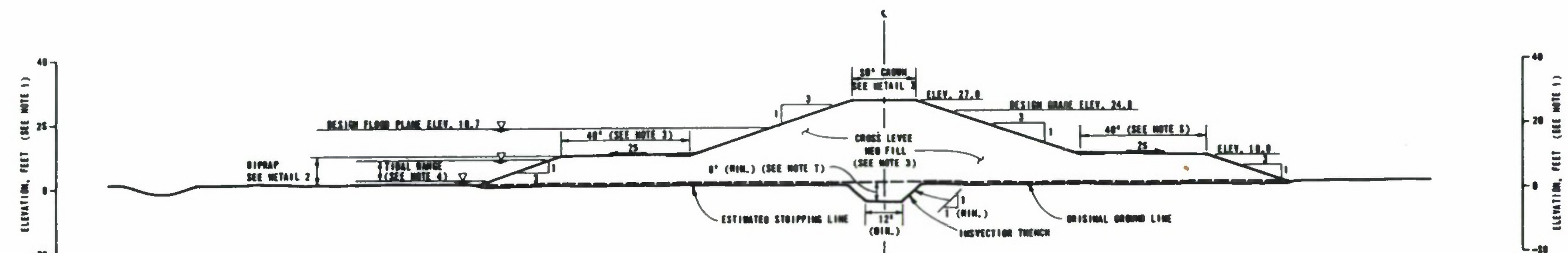
NOTES:
1. ELEVATIONS REFER TO CORPS OF ENGINEERS DATUM WHICH IS 3 FEET BELOW NATIONAL GEODETIC VERTICAL DATUM OF 1929 AT THIS SITE.
2. THE EXISTING LEVEE CROWN IS A PROJECTION OF THE MAXIMUM LEVEE GRADE FROM TOPOGRAPHIC MAPS ONTO THE TRAVERSE PROFILE.
3. REFER TO SHEET 2 FOR TRAVERSE ALIGNMENT DATA. REFER TO SHEET 10 FOR CROSS LEVEE ALIGNMENT DATA.
4. WITHIN THE SECTIONS WHERE MINOR FILL AND SHAPING OF THE EXISTING LEVEE CROWN ARE CALLED FOR, THIS WORK IS ONLY REQUIRED TO BRING THE EXISTING LEVEE GRADE UP TO DESIGN GRADE IN AREAS WHERE A 20-FOOT CROWN WIDTH AT DESIGN GRADE DOES NOT ALREADY EXIST. NO WORK IS REQUIRED WITHIN THESE AREAS WHERE THE CROWN WIDTH AND THE EXISTING GRADE ARE NOT DEFICIENT.
5. RIPRAP IS CALLED FOR FOR WATERSIDE SLOPE PROTECTION WITHIN THE EXISTING LEVEE STUDY AREA NORTH OF THE CROSS LEVEE. THIS WORK IS REQUIRED WHERE RIPRAP DOES NOT ALREADY EXIST.

SCALES
200 0 200 FEET HORIZONTAL
10 0 10 FEET VERTICAL

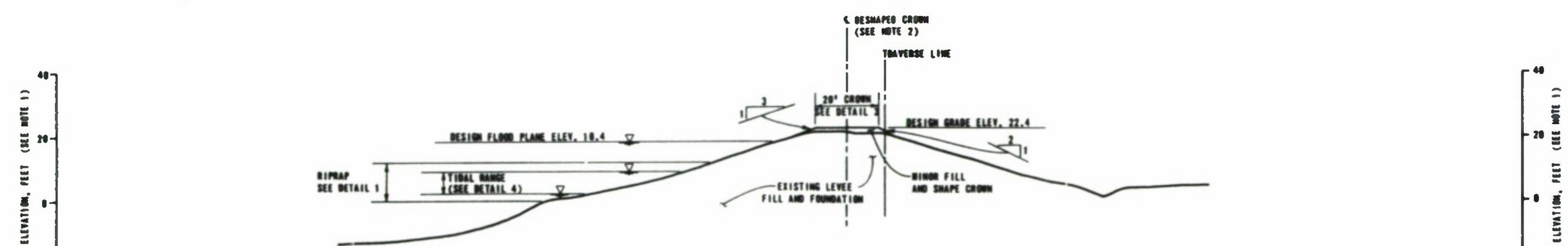
Wahler Associates	DEPARTMENT OF THE ARMY, SACRAMENTO DISTRICT, CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
DESIGNED: S. R. GLIDE	CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
DRAWN: R. T. TARCZY	CROSS LEVEE DESIGN
CHECKED: E. V. RODDA	PROFILE
SUBMITTED: [signature]	SHEET 19/21 · FILE No. 50-10-5757



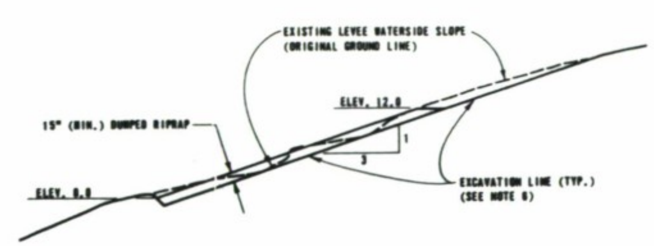
SECTION A-A' AT TRAVERSE STA. 37+40
EXISTING LEVEE - MINOR FILL AND SHAPE CROWN
(SEE SHEET 18)
SCALE: 1" = 20'



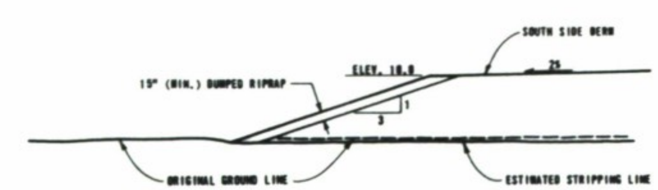
SECTION B-B' AT CROSS LEVEE STA. 10+50
CROSS LEVEE - NEW FILL
(SEE SHEET 18)
SCALE: 1" = 20'



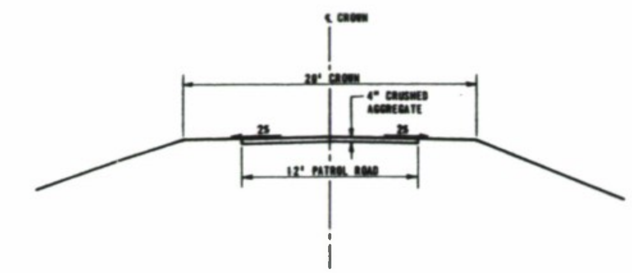
SECTION C-C' AT TRAVERSE STA. 146+85
EXISTING LEVEE - MINOR FILL AND SHAPE CROWN
(SEE SHEET 18)
SCALE: 1" = 20'



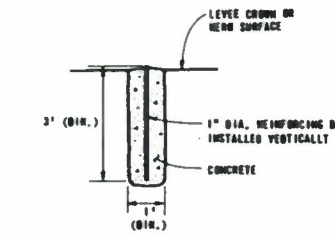
DETAIL 1
EXISTING LEVEE - TYPICAL WATERSIDE SLOPE RIPRAP
(SEE NOTE 5)
SCALE: 1" = 10'



DETAIL 2
CROSS LEVEE - SOUTH SLOPE RIPRAP
SCALE: 1" = 10'



DETAIL 3
LEVEE CROWN
SCALE: 1" = 6'



DETAIL 4
SETTLEMENT MONUMENT
(SEE SHEET 18)
SCALE: 1" = 2'

NOTES:

1. ELEVATIONS REFER TO CORPS OF ENGINEERS DATUM WHICH IS 3 FEET BELOW NATIONAL GEODETIC VERTICAL DATUM OF 1929 AT THIS SITE.
2. THE ALIGNMENT OF THE LEVEE CROWN WHERE MINOR FILL AND SHAPING OF THE CROWN ARE REQUIRED FOR THE EXISTING LEVEE IS CONTROLLED BY MAINTAINING AN OVERALL EFFECTIVE WATERSIDE SLOPE OF 3 HORIZONTAL TO 1 VERTICAL AS ILLUSTRATED BY SECTIONS A-A' AND C-C'.
3. THE DESIGN OF THE CROSS LEVEE AS SHOWN ON SECTION B-B' IS BASED ON THE PRIMARY SOURCE OF FILL BEING DERIVED FROM POTENTIAL BORROW AREA A (SHEET 18). THE USE OF EXISTING LEVEE FILL MATERIAL FROM POTENTIAL REGRADING EXCAVATING OF THE EXISTING LEVEE SOUTH OF THE CROSS LEVEE AS A PRIMARY BORROW SOURCE FOR CROSS LEVEE FILL WOULD REQUIRE THE CROSS LEVEE BERMS TO BE WIDENED FROM 45 FEET TO 60 FEET.
4. THE TIDAL RANGE INDICATED ON THE SECTIONS IS BASED ON CURRENT TIDAL INFORMATION FOR THE LOCATION OF RIO VISTA, ADJUSTED FOR THIS SITE BY ADDING 0.5 FEET AS PER THE CORPS OF ENGINEERS DIRECTION. THIS RESULTS IN A MAXIMUM TIDAL RANGE FROM ELEVATION 5.3 TO ELEVATION 0.5 (CORPS OF ENGINEERS DATUM).
5. RIPRAP IS CALLED FOR FOR WATERSIDE SLOPE PROTECTION WITHIN THE EXISTING LEVEE STUDY AREA NORTH OF THE CROSS LEVEE. THIS WORK IS REQUIRED WHERE RIPRAP DOES NOT ALREADY EXIST.
6. EXCAVATION AND SHAPING OF THE EXISTING LEVEE WATERSIDE SLOPE TO A TYPICAL 3 HORIZONTAL TO 1 VERTICAL SLOPE, AS ILLUSTRATED BY TYPICAL DETAIL 1, IS REQUIRED WHERE SLOUGHING AND CAVING HAVE CREATED LOCALLY OVERSTEEPENED SLOPES, IN ORDER TO PROVIDE AN ADEQUATE SURFACE FOR RIPRAP PLACEMENT. ONLY SHAPING TO SMOOTH IRREGULARITIES IS REQUIRED WHERE THE EXISTING SLOPE IN THE AREA TO RECEIVE RIPRAP IS ALREADY 3 HORIZONTAL TO 1 VERTICAL OR FLATTER.
7. EXCAVATION OF THE CROSS LEVEE INSPECTION TRENCH TO THE DEPTH INDICATED IS SUBJECT TO GROUNDWATER CONDITIONS. THE EXCAVATION MAY BE LIMITED TO A DEPTH LESS THAN 6 FEET IF THE GROUNDWATER LEVEL IS ABOVE THE BOTTOM OF THE TRENCH AND DEWATERING FOR EXCAVATION AND BACKFILLING IN THE DRY REQUIRES MORE THAN SIMPLE DITCHES AND SUMPS.

REVISION	DATE	DESCRIPTION	BY	BY

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: S. R. GLINE
DRAWN: R. T. TARCZY
CHECKED: R. F. RUDDA

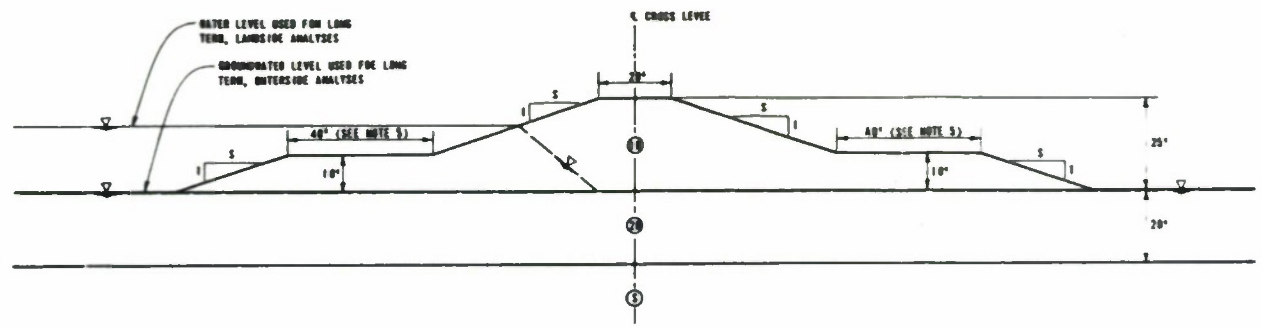
CACHE SLOUGH AND RIGHT BANK OF YOLO BY-PASS LEVEES
CROSS LEVEE DESIGN
SECTIONS AND DETAILS

SUBMITTED: [signature]
DATE APPROVED:
SCALE:
SPEC. No.
SHEET 20/21
FILE No. 50-10-5757

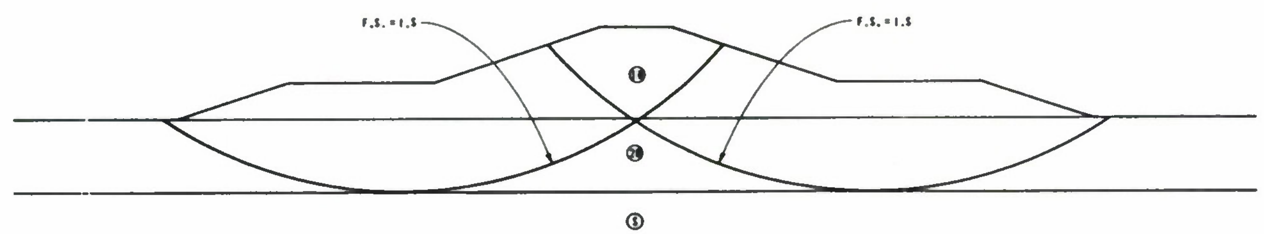
PLATE 20

ENVIRONMENTAL ENHANCEMENT AND ENGINEERING

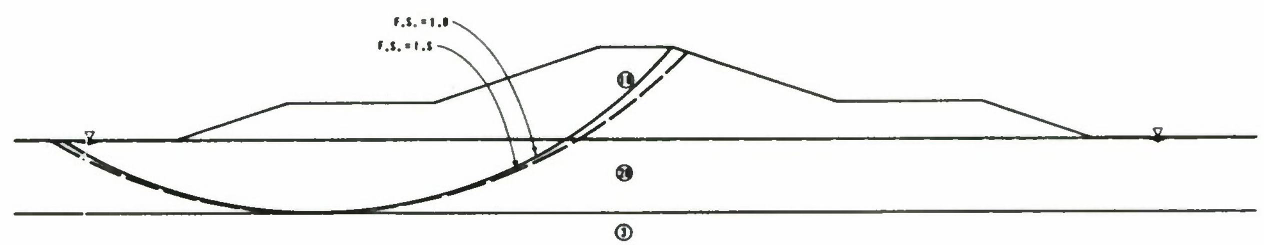
FUNCTIONAL ANALYSIS - VE PAYS



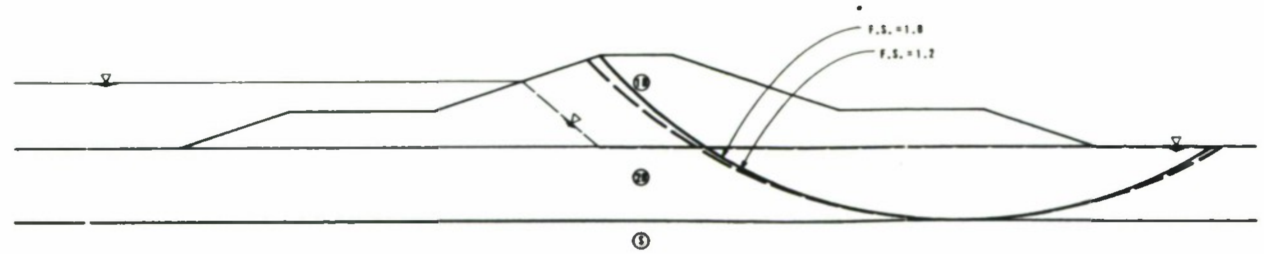
CROSS LEVEE - STABILITY ANALYSIS SECTION
SCALE: 1"=20'



CROSS LEVEE - STABILITY ANALYSIS RESULTS
END OF CONSTRUCTION
SCALE: 1"=20'



CROSS LEVEE - STABILITY ANALYSIS RESULTS
LONG TERM AND EARTHQUAKE - WATERSIDE SLOPE
SCALE: 1"=20'



CROSS LEVEE - STABILITY ANALYSIS RESULTS
LONG TERM AND EARTHQUAKE - LANDSIDE SLOPE
SCALE: 1"=20'

SOIL PARAMETERS USED IN STABILITY ANALYSES

MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT (pcf)	SHEAR STRENGTH: END OF CONSTRUCTION COHESION (psf)	SHEAR STRENGTH: END OF CONSTRUCTION FRICTION ANGLE (degrees)	SHEAR STRENGTH: LONG TERM AND EARTHQUAKE COHESION (psf)	SHEAR STRENGTH: LONG TERM AND EARTHQUAKE FRICTION ANGLE (degrees)
1	FILL - BORROW (SEE NOTE 5)	130	1200	15	240	22.25
2	SOFTER FOUNDATION - BEYOND TOE OF EXISTING LEVEE	85	300	0	200	10
3	STIFFER FOUNDATION	125	SEE NOTE 3			

SUMMARY OF STABILITY ANALYSES RESULTS

CONDITION	REQUIRED MINIMUM FACTOR OF SAFETY	CALCULATED MINIMUM FACTOR OF SAFETY: WATERSIDE SLOPE	CALCULATED MINIMUM FACTOR OF SAFETY: LANDSIDE SLOPE
END OF CONSTRUCTION	1.3	1.5	1.5
LONG TERM - STATIC	1.4	1.8	1.8
LONG TERM - PSEUDOSTATIC (0.1g)	1.0	1.5	1.5

LEGEND

- ASSUMED WATER LEVEL
- ASSUMED PHREATIC SURFACE
- CRITICAL CIRCLE - STATIC
- CRITICAL CIRCLE - PSEUDOSTATIC (SEISMIC COEFFICIENT = 0.1g)

NOTES:

1. SHEAR STRENGTH PARAMETERS USED IN THE STABILITY ANALYSES AND REQUIRED MINIMUM FACTORS OF SAFETY FOR VARIOUS CONDITIONS OF ANALYSIS ARE IN ACCORDANCE WITH SLOPE STABILITY CRITERIA IN ENGINEERING MANUAL EM 1110-2-1913, DESIGN AND CONSTRUCTION OF LEVEES.
2. STABILITY ANALYSES RESULTS FACTORS OF SAFETY WERE DETERMINED USING BISHOP'S MODIFIED METHOD FOR CIRCULAR ARC ANALYSIS.
3. BECAUSE OF THE SIGNIFICANTLY GREATER STRENGTH IN THE STIFFER FOUNDATION, STABILITY ANALYSES WERE PERFORMED SUCH THAT POTENTIAL FAILURE SURFACES REMAIN WITHIN THE SOFTER FOUNDATION AND DO NOT PASS THROUGH THE UNDERLYING STIFFER FOUNDATION. THEREFORE, IDENTIFICATION OF SHEAR STRENGTH PARAMETERS FOR THE STIFFER FOUNDATION FOR USE IN STABILITY ANALYSES IS NOT NECESSARY.
4. NO PHREATIC SURFACE WAS USED IN THE CROSS LEVEE, END OF CONSTRUCTION STABILITY ANALYSIS FOR THE PURPOSE OF DEFINING PORE PRESSURES BECAUSE THIS IS A TOTAL STRESS ANALYSIS BASED ON TOTAL STRESS STRENGTH PARAMETERS.
5. THE STABILITY ANALYSIS OF THE CROSS LEVEE SECTION IS BASED ON BORROW BEING DERIVED FROM POTENTIAL BORROW AREA A (SHEET 15). THE USE OF EXISTING LEVEE FILL MATERIAL FROM POTENTIAL DEGRADING EXCAVATION OF THE EXISTING LEVEE SOUTH OF THE CROSS LEVEE FOR CROSS LEVEE FILL WOULD REQUIRE THE CROSS LEVEE BERMS TO BE WIDENED FROM 40 FEET TO 60 FEET TO MEET THE MINIMUM REQUIRED END OF CONSTRUCTION FACTOR OF SAFETY. THIS IS BASED ON AN ESTIMATED UNCONSOLIDATED UNDRAINED SHEAR STRENGTH OF c=1000 PSF, φ=0 DEGREES FOR RECOMPACTED EXISTING LEVEE FILL MATERIAL AND SHOULD BE CONFIRMED IF THE OPTION OF EXISTING LEVEE DEGRADING FOR A SOURCE OF BORROW IS USED.

SCALE
20 0 50 FEET

REVISION	DATE	DESCRIPTION	BY	BY

Wahler Associates

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED: S. H. KLINE
DRAWN: M. T. TARCZY
CHECKED: K. V. DODDA
SUBMITTED: [signature]
DATE APPROVED:

CACHE SLOUGH AND RIGHT BANK
OF YOLO BY-PASS LEVEES
CROSS LEVEE DESIGN
STABILITY ANALYSES RESULTS

SCALE: | SPEC. No.
SHEET 21/21 | FILE No. 50-10-5757

PLATE 21

SAFETY PAYS

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

TO: Defense Technical Information Center
ATTN: DTIC-O
8725 John J. Kingman Road, Suite 0944
Fort Belvoir VA 22060-6218

22 October 2008

FROM: US Army Corps of Engineers
Sacramento District Library
1325 J Street, Suite 820
Sacramento CA 95814-2292

SUBJECT: Submission of technical reports for inclusion in Technical Reports Database

The enclosed documents from USACE Sacramento District are hereby submitted for inclusion in DTIC's technical reports database. The following is a list of documents included in this shipment:

ADB344304 • Lemon Reservoir Florida River, Colorado. Report on reservoir regulation for flood control, July 1974
ADB344333 • Reconnaissance report Sacramento Metropolitan Area, California, February 1989
ADB344346 • New Hogan Dam and Lake, Calaveras River, California. Water Control Manual Appendix III to Master Water Control Manual San Joaquin River Basin, California, July 1983
ADB344307 • Special Flood Hazard Study Nephi, Utah, November 1998 (cataloged)
ADB344344 • Special Study on the Lower American River, California, Prepared for US Bureau of Reclamation – Mid Pacific Region and California Dept. of Water Resources..., March 1987
ADB344313 • Transcript of public meeting Caliente Creek stream group investigation, California, held by, the Kern County Water Agency in Lamont, California, 9 July 1979
ADB344302 • Initial appraisal Sacramento River Flood control project (Glenn-Colusa), California, 10 February 1989
ADB344485 • Report on November-December 1950 floods Sacramento-San Joaquin river basins, California and Truckee, Carson, and Walker rivers, California and Nevada, March 1951
ADB344268 • Reexamination Little Dell Lake, Utah, February 1984
ADB344197 • Special report fish and wildlife plan Sacramento River bank protection project, California, first phase, July 1979
ADB344264 • Programmatic environmental impact statement/environmental impact report Sacramento River flood control system evaluation, phases II-V, May 1992
ADB344201 • Hydrology office report Kern river, California, January 1979
ADB344198 • Kern River – California aqueduct intertie, Kern county, California, environmental statement, February 1974
ADB344213 • Sacramento river Chico Landing to Red Bluff, California, bank protection project, final environmental statement, January 1975
ADB344265 • Cottonwood Creek, California, Information brochure on selected project plan, June 1982
ADB344261 • Sacramento river flood control project Colusa Trough Drainage Canal, California, office report, March 1993
ADB344343 • Detailed project report on Kern River-California aqueduct intertie, Kern County, California, February 1974

- ADB344267 Sacramento River Flood Control Project, California, Right Bank Yolo Bypass and Left Bank Cache Slough near Junction Yolo Bypass and Cache Slough, Levee construction, General Design, Supplement No. 1 to Design Memorandum #13, May 1986
- ADB344246 Redbank and Fancher Creeks, California, General Design Memorandum #1, February 1986
- ADB344260 Cache Creek Basin, California, Feasibility report and environmental statement for water resources development Lake and Yolo counties, California, February 1979
- ADB344199 Sacramento River Deep Water Ship channel, California, Feasibility report and environmental impact statement for navigation and related purposes, July 1980
- ADB344263 Sacramento River flood control project, California, Mid-Valley area, phase III, Design Memorandum, Vol. I or II, June 1986
- ADB344262 Marysville Lake, Yuba River, California, General Design Memorandum Phase I, Plan Formulation, Preliminary Report, Appendixes A-N, Design Memorandum #3, March 1977

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The Sacramento District source code is **410637**. Please return any materials that aren't appropriate for the technical reports database.

Please acknowledge receipt of shipment by sending email message to Frances.J.Sweeney@usace.army.mil.

Thank you,

Frances J. Sweeney
Library Manager
USACE, Sacramento District Library
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